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An Assessment of Newfoundland and Labrador Snow Crab in 2001

Évaluation des stocks de crabe des neiges de Terre-Neuve et du Labrador pour l'année 2001

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Abstract

Data from the commercial fishery since 1973, as well as 1995-2001 survey data were used to infer resource status of Newfoundland and Labrador snow crab (*Chionoecetes opilio*) for the 2002 fishery. Annual trends in landings, effort and catch per unit effort (CPUE) throughout NAFO Div. 2J3KLNO were reviewed and updated for 2001. CPUE from offshore fleets increased in the late 1980's and have remained generally high, although they declined after 1998 in Div. 2J3K. This reflects recent high commercial biomass relative to that of the mid 1980's overall that is decreasing in the north. Data utilized from the Div. 2J3KLNO 2001 fall multispecies bottom trawl surveys during 1995-2001 included catch rate, size (carapace width, CW), sex, maturity, egg development and molt status (shell condition and chela allometry). These surveys are conducted near the end of the fishing season and so are considered to provide an index of post-fishery biomass. Legal-sized and prerecruit males were broadly distributed throughout much of the survey area but were absent from Div. 2GH and 3M, some inshore areas, and across much of the shallow southern Grand Bank. These surveys indicate that the exploitable biomass decreased between 1999 and 2000 and has remained stable since then. The exploitable biomass available to the Div. 2J3KLNO fishery in 2002 is expected to be not substantially different from that of the previous two years. The biomass of immediate prerecruits decreased during 1997-2000, increased in 2001 and has remained unchanged for 2002. However there is high uncertainty associated with these trends in exploitable biomass and prerecruits because of variable catchability of crabs by substrate type. The ratio of catch to the projected exploitable biomass index has increased steadily from 1997-2001, implying an increase in exploitation rate. Annual trends in exploitable biomass indices agree with trends in fishery performance in northern areas, especially in Div. 2J, whereas these indices for Div. 3L are in opposition. However there is high uncertainty about both indices because the fishery data are not standardized for effects of annual changes in fishing practices, and the survey series does not account for strong effects of crab size and substrate type on catchability by the survey trawl. The apparent increase in exploitation rate has had minimal impact on reproductive potential. Abundance of mature females has declined since 1995 throughout Div. 2J3KLNO but sex ratios of adults continue to favor males and there is no evidence of any decrease in mating success of females. Resource status and prospects for Subdiv. 3Ps or Div. 4R are uncertain because of a lack of fishery-independent data. Offshore CPUE in Subdiv. 3Ps increased steadily to 1999 and has since declined, but remains above the low level of the 1980's. Div. 4R CPUE has remained stable over the past 4 years at a lower level than in other divisions.

Résumé

Aux fins de la pêche en 2002, l'état de la ressource en crabe des neiges (Chionoecetes opilio) à Terre-Neuve-et-Labrador est déduit d'après les données de la pêche commerciale recueillies depuis 1973 et les données des relevés effectués de 1995 à 2001. Les tendances annuelles des débarquements, de l'effort et des prises par unité d'effort (PUE) à l'échelle des divisions 2J3KLNO de l'OPANO ont été passées en revue et mises à jour d'après les données pour 2001. La PUE des flottilles hauturières a augmenté à la fin des années 1980 pour ensuite demeurée relativement élevée, quoiqu'elle ait diminué après 1998 dans les divisions 2J3K. Cette tendance reflète la récente forte biomasse de crabe de taille commerciale par rapport à celle du milieu des années 1980, qui en général est à la baisse dans le nord. Les données utilisées portaient sur le taux de capture, la taille (largeur de carapace, LC), le sexe, le stade de maturité, le stade de développement des œufs et le stade de mue (condition de la carapace et allométrie des chélipèdes) issues des relevés polyvalents d'automne au chalut de fond effectués dans les divisions 2J3KLNO de 1995 à 2001. Comme ces relevés sont effectués vers la fin de la saison de pêche, on considère qu'ils donnent un indice de la biomasse qui reste après la pêche. Des mâles de taille légale et des prérecrues mâles étaient largement répartis dans une grande partie de la zone des relevés, mais ils étaient absents des divisions 2GH et 3M, de certains secteurs côtiers et d'une grande partie du secteur sud peu profond du Grand Banc. Les relevés indiquent que la biomasse exploitable a diminué entre 1999 et 2000, mais qu'elle est stable depuis. On prévoit que la biomasse exploitable disponible pour la pêche dans les divisions 2J3KLNO en 2002 ne sera pas très différente de celle des deux années précédentes. La biomasse de prérecrues a diminué entre 1997 et 2000 puis a augmenté en 2001; elle se situe à ce même niveau en 2002. Une forte incertitude entoure toutefois ces tendances de la biomasse exploitable et de l'abondance des prérecrues en raison de la capturabilité variable des crabes selon le type de substrat. Le rapport entre les prises et l'indice projeté de la biomasse exploitable a augmenté régulièrement entre 1997 et-2001, ce qui peut signifier que le taux d'exploitation a augmenté. Les tendances annuelles de l'indice de la biomasse exploitable concordent aux tendances du rendement de la pêche dans les zones du nord, en particulier dans la division 2J, tandis que l'indice pour la division 3L est en opposition. Une forte incertitude entoure toutefois les deux indices parce que les données sur la pêche ne sont pas normalisées en fonction des effets des changements annuels dans les pratiques de pêche et que la série de relevés ne tient pas compte des effets marqués de la taille de crabes et du type de substrat sur la capturabilité au chalut de relevé. L'augmentation apparente du taux d'exploitation a eu peu d'incidence sur le potentiel de reproduction. L'abondance des femelles matures diminue depuis 1995 à l'échelle des divisions 2J3KLNO, mais le rapport de masculinité des adultes continue à favoriser les mâles et rien n'indique une baisse du succès de l'accouplement des femelles. L'état et les perspectives de la ressource dans la sous-division 3Ps et la division 4R sont incertains à cause d'un manque de données indépendantes de la pêche. La PUE dans les eaux hauturières de la sous-division 3Ps a augmenté de façon constante jusqu'en 1999 mais a diminué depuis, tout en demeurant au-dessus du faible niveau des années 1980. La PUE dans la division 4R, inférieure à celle dans d'autres divisions, est restée stable au cours des quatre dernières années.

Introduction

The Newfoundland and Labrador snow crab (*Chionoecetes opilio*) fishery began in 1968 and was limited to NAFO Divisions 3KL until the mid1980's. It has since expanded throughout Divisions 2J3KLNOP4R and is prosecuted by several fleets. The resource declined during the early 1980's but then recovered and has remained very large throughout the 1990's. Management of the increasingly diverse fishery led to the development of 41 quota-controlled areas with over 3500 licence/permit holders under enterprise allocation by 1999. Management areas (Fig. 1) hold no relationship with biological units and it is not possible to provide reliable scientific advice at this fine scale of management

The fishery is prosecuted using conical baited traps set in longlines The minimum legal size is 95 mm CW. This regulation excludes females from the fishery while ensuring that a portion of the adult males in the population remain available for reproduction. The minimum legal mesh size of traps is 135 mm., to allow small crabs to escape. Under-sized and soft-shelled males that are retained in the traps must be returned to the sea and an unknown proportion of those die.

This document presents commercial fishery and research survey data toward evaluating the status of the Newfoundland and Labrador snow crab (*Chionoecetes opilio*) resource throughout NAFO Div. 2J3KLNOP4R in 2001. Trends in landings, fishing effort and catch per unit of effort (CPUE) are reviewed and updated for 2001. Data from the fall Div. 2J3KLNO 1995-2001 multispecies bottom trawl surveys are presented to provide information on trends in distribution, size composition, and exploitation rate over the time series as well as to infer changes in exploitable biomass and recruitment for the 2001 fishery. These survey data have been used in annual snow crab assessments since 1997 (Dawe et al. 2001).

Methodology

Fishery Data

Total commercial catch was taken from the quota report. More detailed raw data on commercial catch (kg) and fishing effort (number of trap hauls) were obtained from vessel logbooks. These data were compiled by the Statistics Divison, Policy and Economics Branch, Newfoundland Region of the Department of Fisheries and Oceans. Catch per unit of effort (CPUE, kg/trap haul) was calculated by year and NAFO Division. CPUE is used as an index of biomass, but it is unstandardized in that it does not account for variation in catch or effort levels, seasonality of fishing, or other fishing practices (eg. soak time and mesh size). Not all of the total catch or effort were reported in the logbooks, and some of the logbook data were not useable, so total fishing effort was calculated as the ratio of the total catch to the logbook-derived CPUE. The spatial distribution of fishing effort was described from fishing positions reported in the logbooks. Spatial coverage of the fishery based on availability of logbook data varied over the years. There were no logbook data available from inshore areas (small boat fleet, <35 ft.) before 1997 and data were most extensive from the inshore 2000 and 2001 fisheries.

Survey Data

Data on total catch numbers and weight were acquired from the 1995 to 2001 fall stratified random bottom trawl surveys, which extended throughout NAFO Div. 2J3KLNO. The 1996-98 surveys also extended to NAFO Div. 2GH and to inshore strata, not included in the 1995 and 1999 surveys. Inshore strata were also surveyed in 2000 and 2001. These surveys utilized the Campelen 1800 survey trawl in standard tows of 15 min. duration.

Snow crab catches from each set were sorted, weighed and counted by sex. Catches were sampled in their entirety or subsampled by sex. Individuals of both sexes were measured in carapace width (CW, mm) and shell condition was assigned one of three categories: (1) new-shelled - these crab had molted in spring of the current year, have a low meat yield throughout most of the fishing season, and are generally not retained in the current fishery until fall; (2) intermediate-shelled – these crab last molted in the previous year and are fully recruited to the fishery throughout the current fishing season; (3) old-shelled – these crab have been available to the fishery for at least 2 years. Males were also sampled for chela height (CH, 0.1 mm). Maturity status was determined for females and relative fullness and stage of development of egg clutches were assessed.

A schematic model of snow crab recruitment (Dawe et al. 1997) was followed in assigning males to population components for subsequent analysis. Based on this model, males were grouped into classes for each of three biological variables:

i) Carapace Width (CW) – based on growth per molt data (Moriyasu et al. 1987, Taylor and Hoenig 1990, and Hoenig et al. 1994), three main size groups were established: legal-sized males (≥95 mm CW); Sub-legal 1, those which would achieve legal size after one molt (76-94 mm CW); and Sub-legal 2, those which would achieve legal size after two molts (60-75 mm CW). All other males were pooled into a category of small males (<60 mm CW).

i) Chela Allometry – males develop enlarged chelae when they undergo a final molt, which may occur at any size larger than about 40 mm CW. Therefore only males with small chelae will continue to molt and subsequently recruit to the fishery. A model which separates two 'clouds' of chela height on carapace width data ($CW = 0.0806CH^{1.1999}$) was applied to classify each individual as either adult (large-clawed) versus adolescent or juvenile (small-clawed).

ii) Shell Hardness – males that undergo their terminal molt in the spring will remain new-shelled throughout the fishery season of that year and will not be fully hardened until the following year. Therefore new-shelled legal-sized crabs are not considered to be part of the exploitable biomass, although it is recognized that some of these males are retained by the fishery late in the season (in fall). It is assumed that all males with small chelae molt each spring and so remain new-shelled between molts. In reality, however, an annually variable proportion of small-clawed males will not molt in any given year ('skip molters') and so will develop 'older shells' between molts. For each year that a crab skips a molt, it's eventual recruitment is delayed by a year.

Spatial distribution was compared between 2000 and 2001 for Div. 2J3KLNO using the fall survey data. ACON (G. Black, pers. com.) was used to describe density distribution of each of the four size groups of males described above; legal-sized (>94 mm CW), Sub-legal 1 (76-94 mm CW, Sub-legal 2 (60-75 mm CW), and small males (<60 mm CW). Distribution of mature females was also described.

To examine size composition of males, carapace widths were grouped into 3 mm intervals and adjusted up to total population abundance. Each size interval was partitioned, based on chela allometry, between juveniles plus adolescents versus adults.

Indices of the exploitable biomass and of prerecruit biomass were projected for the years 1996-2002, from fall surveys in the preceeding year, using STRAP (Smith and Somerton 1981). The

exploitable biomass index was calculated as the fall survey biomass index of adult (large-clawed) legal-sized (>95 mm CW) males, regardless of shell condition. Adult males are terminally molted, so that no members of this category would molt in spring and all adults in the fall survey (including new-shelled adults) would be fully recruited to the fishery in the following year. The prerecruit index was calculated by applying a 19 mm CW growth increment (Hoenig et al. 1994) to all adolescent (small-clawed) males larger than 75 mm CW caught in the preceeding fall survey, before applying STRAP. The resultant projected biomass index represented a component of legal-sized (>95 mm CW) males that had recently molted, were new-shelled and not recruited to the fishery of the current year, and would begin to recruit (as older-shelled males) in the following year. However, some of these recently molted males would have remained adolescent, and so would molt one more time before achieving adulthood and subsequently recruiting to the fishery, as older-shelled males, one additional year later (ie. 3 years from the survey year).

These projected biomasses must be recognized as indices rather than absolute estimates because it is known that the catchability of the survey trawl is much lower than 1.0 (Dawe et al. 2002), and so these projections considerably underestimate absolute biomass. Projection of biomass indices does not account for annual variability in natural mortality or in the proportion of adolescent males that do not molt in the following spring (skip-molters). Biomass indices are only approximately comparable among years because of annual variation in survey coverage. However survey strata are selected to be comparable for the most recent two years and, for the 2000 and 2001 fall surveys, included inshore strata.

The ratio of the annual catch to the projected exploitable biomass index was calculated. It is recognized that this ratio greatly underestimates true exploitation rates because of the low catchability of crabs by the survey trawl. Also, annual changes in this ratio may be due to changes in catchability rather than exploitation rate. However we feel that long term trends (since 1996) may provide a useful indication of trends in exploitation rates. Inshore catches were not included in calculating the ratios for 1996 and 2000, because inshore survey strata were not included in the exploitable biomass indices that were projected for those years.

Results and Discussion

Fishery Performance

Annual trends

Landings for Divisions 2J3KLNOP4R combined increased steadily from about 10,000 t annually during the late 1980's (Fig. 2) to 69,036 t in 1999 (Table 1, Fig. 2) largely due to expansion of the fishery to offshore areas as annual total allowable catches (TAC's) and number of participants increased. Total fishing effort increased by 20% from 1996-1998, and further increased by 30% to more than 4.5 million trap hauls in 1999 (Table 2). Landings decreased by 19% to 55,639 t in 2000, as fishing effort decreased by 20%, in association with a 17% reduction in overall TAC (Table 1). Landings increased slightly to 56,705 t in 2001, due to a similar (2%) increase in the overall TAC, while effort increased by 11%.

Fishing effort was broadly distributed in 2001. The spatial distribution of effort was very similar between 2000 and 2001 (Fig. 3). This suggests that prospects for further expansion of the fishery are limited.

The overall CPUE increased slightly from 12.9 kg/trap haul in 1996 to 15.0 kg/trap haul in 1999 (Table 2) and remained virtually unchanged during 1998-2000. It declined slightly to 13.9 kg/trap haul in 2001, but remained very high, slightly exceeding the overall 1996 level.

Division 2J3KLNO.

Landings along the continental shelf from southern Labrador to the southern Grand Bank (Div. 2J3KLNO) increased from about 6,000 t in 1987 to 59,521 t in 1999 (Fig. 2), due largely to increases in TAC's. Landings frequently exceeded TAC's (Table 1) because of additional special exploratory allocations. The TAC was set at 52,155 t in 1999 (Table 1), the first year of the past 3-year management plan, but was reduced to 42,039 t for 2000. Meanwhile, landings decreased by 23% to 46,082 t in 2000, due to reductions in TAC and exploratory allocations. The TAC increased to 43,113 t in 2001 and landings increased to 47,187 t.

The reductions in TAC and landings in 2000 were due to a projected decrease in exploitable biomass (Dawe et al. 2001). These decreases were projected to be greater in northern areas (Div. 2J3K) than in the more southern areas (Div. 3LNO), and, accordingly, TAC's and landings were respectively reduced by 26-27% and 28-30% in Div. 2J and 3K in 2000, whereas they were reduced by only 14% in Div. 3L (Table 1). Landings in Div. 3NO decreased by 39% in 2000, due to a 25% reduction in TAC together with reductions in special exploratory allocations. TAC's increased slightly in all divisions except Div. 3NO in 2001; meanwhile landings decreased slightly in Div. 2J3K, but increased by 5% and 3% in Div. 3L and Div. 3NO respectively (Table1).

Fishing effort increased by 48% across all divisions (Div. 2J3KLNO) from 2.62 to 3.86 million trap hauls during 1996-1999 (Table 2), before decreasing by 23% in 2000. Effort increased by 10% in 2001, in association with a 2% increase in landings. CPUE increased steadily across all divisions from 13.0-15.6 kg/trap haul during 1996-2000 and decreased slightly, while remaining at a high level (14.6 kg/trap haul), in 2001.

Because of changes in management measures as well as spatial and temporal changes in fishing practices, year-to-year changes in CPUE may not reflect changes in stock status. However, it is considered possible to interpret catch rates in the context of longer-term trends. Long-term trends in commercial catch rates, for Div 3K and 3L in particular (Fig. 4), indicate that CPUE peaked in 1981, declined subsequently to record low levels in 1987, and subsequently increased to very high levels. Annual trends in offshore CPUE reflect considerable differences among divisions in recent years (Fig. 4). CPUE has continued to increase in recent years in Div. 3L and Div. 3NO, achieving record high values of 19.0 and 21.2 kg/trap haul respectively in 2001 (Table 2, Fig. 4). However, CPUE peaked in 1998 in more northern Div. 3K (14.2 kg/trap haul) and Div. 2J (14.5 kg/trap haul) and subsequently declined regularly to 11.2 kg/trap haul (Div. 3K) and 8.8 kg/trap haul (Div. 2J) in 2001. The 2001 CPUE for Div. 2J approximates the low levels previously observed in 1995 (7.9 kg/trap haul) and 1987 (8.5 kg/trap haul). Generally, these trends reflect recent high commercial biomass relative to that of the mid 1980's overall that is decreasing in the north.

Subdivision 3Ps.

Landings increased from about 600 t when the fishery began in 1985 to 7,917 t in 2000 and remained virtually unchanged (7,843 t) in 2001 (Table 1, Fig. 2). The TAC was 7,700 t during 1999-2000 and 7,600 t in 2001. TAC's have been reached or exceeded each year. Inshore landings have accounted for about 45% of the total landings during 1999-2001.

The offshore commercial catch rate was initially low and stable, ranging 3.0-4.8 kg/trap haul during 1987-1991, before increasing steadily to 23.4 kg/trap haul in 1999 (Fig. 4) CPUE has

since declined to 15.7 kg/trap haul in 2001 (Table 2), comparable to the 1994 level (15.2 kg/trap haul) and remaining above the low level of the 1980's. Fishing effort increased steadily from 183 to 499 thousand trap hauls since 1996 (Table 2).

Division 4R.
Landings increased from about 650 t when the fishery began in 1994 to 1,063 t in 1998 (Fig. 2). The TAC increased from 1,330 t in 1999 to 1,430 t in 2000 and 1,539 t in 2001. Landings further increased to 1,612 t in 1999 due to TAC increases and remained virtually unchanged in 2000 (1,640 t) and 2001 (1,675 t). TAC's have not been reached in some years.

The commercial catch rate has been consistently much lower than in other divisions (Fig. 4), ranging only 3.6-5.9 kg/trap haul throughout the 8-year time series. CPUE has remained stable, ranging 4.4-5.1 kg/trap haul, within the past 4 years (Table 2). Fishing effort more than doubled from 1996 to 1999, before declining by 12% in 2000 and remaining virtually unchanged, at 328 thousand trap hauls, in 2001 (Table 2).

Seasonal trends

Div. 2J3KL.
The seasonal distributions of catch and fishing effort for Div. 2J3KL in 2001 were quite similar to those of the previous year (Fig. 5). Most of the annual fishing effort in Div. 3K and 3L was expended by the end of July, although both fishing effort and catch in Div. 3K peaked one month later in 2001 (July) than in 2000. The fishery in Div. 2J was shifted slightly later than in more southern Div. 3KL, with most of the catch and effort expenditure occurring during June-August in both 2000 and 2001 (Fig. 5).

The Div. 2J fishery performed consistently more poorly in all months of 2001 than in 2000. CPUE declined steadily in 2001 from 13.8 kg/trap haul in June to 4.8 kg/trap haul in November. There was no clear difference in fishery performance between the past two years in Div. 3KL, especially for the early portion of the season (May-July) when most fishing took place (Fig. 5). However CPUE declined steadily in both those divisons in 2001 achieving much lower August and September catch rates in 2001 than in 2000. We recognize however that these late-season comparisons are based upon scanty catch and effort data (Fig. 5).

Subdivision 3Ps.
The seasonal distribution of catch in 2001was quite similar to that of the previous year, with most of the catch being taken during May-July of both years (Fig. 6). Effort expenditure generally reflected the catch trends but was higher in 2001 than in 2000 throughout June-August. The fishery performed consistently more poorly in all months of 2001 than in 2000, but especially in the later months of July and August.

Division 4R.
The fishery has primarily been prosecuted during April-June in both 2000 and 2001, with very little effort expenditure after June, especially in 2001 (Fig.6). Although based on scanty data, CPUE was lower in 2001 than in 2000 throughout August to October.

Fall Surveys-Division 2J3KLNO

Spatial distribution

The fall distribution of males throughout NAFO Div. 2J3KLNO in 2001 was very similar to that in 2000 (Fig. 7) and, generally, to the distribution pattern observed throughout 1996-2000, as

previously described (Dawe et al. 2001, Dawe and Colbourne 2002). Males were broadly distributed throughout most of the Div. 2J3KLNO survey area. They were absent from the deepest sets (>500 m) along the Div. 3K slope, but they extended to greater depths along the more northern Div. 2J slope and along the more southern Div. 3LN slope. Largest (legal-sized) males predominated along the Div. 3LN slope (Fig. 7a). Largest males (Fig. 7a) were also usually absent from innermost sets at depths <300 m in Div. 2J3K where small males were caught (Fig. 7c-d). Snow crabs of both sexes and all sizes were virtually absent over a broad area of the shallow (<100 m) southern Grand Bank (Fig. 7). The distribution of mature females (Fig. 7e) continued to be similar to that of comparably-sized males (Fig. 7c-d).

Trends in distribution over the 1995-2000 period were reviewed by Dawe et al. (2001) and Dawe and Colbourne (2002). These trends included gradual spatial shifts in highest densities of most size groups, but also sharp annual and area-specific changes in survey catch rates. Most pronounced of such sharp changes was a marked decrease in apparent density of all size groups in Div. 3K in 1999 followed by a sharp increase in 2000, particularly for smallest crabs (Dawe et al. 2001). Such sharp area-specific annual changes in density that occur across both sexes and the entire broad male size range imply considerable spatial and annual variability in catchability by the survey trawl (Dawe and Colbourne 2002). A study in 2001 showed that catchability of snow crabs by the Campelen trawl is considerably lower than 1.0 and varies greatly with both substrate type and crab carapace width (Dawe et al. 2002).

Changes in distribution in 2001 were overall less pronounced than those noted in the previous year, but were again most pronounced for the smallest males (Fig. 7d). Smallest males (<60 mm CW) showed a very sharp increase in catch rate across Div. 3L in 2001. High catch rates of smallest males also expanded southward throughout Div 2J and offshore to the slope of the shelf in all divisions but especially in Div. 3K. These changes in distribution and apparent density (ie. catch rate) in 2001 were also seen in the larger sublegal-sized males (Fig. 7b-c) and in the mature females (Fig. 7c). For these sublegal-sized males, highest catch rates were within the inshore strata in 2001 (Fig. 7b-c).

Offshore expansion was also apparent to some degree for legal-sized males in Div. 3K in 2001 (Fig. 7a), which, together with retraction from the outer shelf and slope, resulted in a clear aggregation of highest catch rates in deep waters (300-500 m) northwest of the Funk Island Bank. Catch rates of legal-sized crabs also decreased somewhat along the southeastern slope of Div. 3L (Fig. 7a), but other changes in this area in 2001 are unclear because of limitations in survey coverage, especially in 2000.

No change in distribution was evident in 2001 in Div. 3NO. Catch rates of legal-sized males remained very high along the eastern slope (Fig. 7a), whereas catch rates of small crabs were low and generally limited to northern Div. 3O. (Fig. 7c-e).

Depth distribution of legal-sized males

Trends in distribution by depth were examined in detail for the most broadly distributed and annually variable portion of the legal-sized male resource (Div. 2J3KL), using the entire 1995-2001 time series (Fig. 8). We note that the depth distribution is not fully represented in 1995 because some strata, including some of the deepest, were not surveyed in that first multispecies survey year. Survey catch rates extended to greatest depths early in the time series, generally during 1996-1998 (Fig. 8). Legal-sized males were caught in those years to maximum depths of 1200 m in Div. 2J, 1000 m in Div. 3K and 1500 m in Div. 3L. However only in Div. 3L were very large (and in some years largest) catch rates achieved at depths exceeding 700 m.

Annual change in depth distribution was most pronounced in Div. 3K, where there was a clear retraction of catch rates from deep to shallow waters over the time series. Substantial catch rates extended to 1000 m in 1996, 900 m in 1997, 700 m in 1998, but only to 500 m in 2001 (Fig. 8). High catch rates similarly retracted from deep waters over the time series in Div. 3L. There, maximum annual catch rates occurred within the range of 800-1200 m during 1996-1998, at 700-1000 m during 1999, at 500-700 m during 2000, and at 100-600 m in 2001. Annual changes are unclear in Div. 2J, but there appears to have been a slight shift to deeper waters in recent years.

The depth distribution of legal-sized males by molt status, as reflected by relative shell age, was examined only for 1996-2001 because shell condition was not reliably staged in 1995. Catch rates of recently molted (new-shelled) males were generally as high or higher than those of males that had not recently molted (old-shelled) throughout 1996-1998 (Fig. 9). This was clearest in Div. 2J. There was a very sharp decrease in the catch rates of new-shelled males relative to old-shelled males in 1999, especially in Div. 2J3K. Catch rates of new-shelled males remained considerably lower during 1999-2001 than during 1996-1998. The sharp decline in relative catch rates of new-shelled crabs in 1999 implies a corresponding decline in recruitment of older-shelled males beginning in 2000. Catch rates of new-shelled males have increased slightly overall in 2001 in Div. 2J3K, but such a possible increase is not apparent in Div. 3L (Fig. 9).

The catch rate of new-shelled relative to old-shelled males tended to be highest at depth intervals greater than 600 m (Fig. 9), with several clear exceptions (eg. Div. 3L in 1997 and 1999). This seems contrary to the expected, because the commercial fishery would presumably have selectively removed older-shelled males from shallower depths. This suggests that large males near the slope may move down-slope to deeper waters to molt. The alternation between years in the relative prominence of new-shelled and old-shelled males in Div. 3L at depths exceeding 600 m further supports this possibility. Older-shelled males that were prevalent at these great depths in 1997 and 1999, were represented as new-shelled males in the preceding years (1996 and 1998 respectively), but were not found at these depths in the following years (1998 and 2000 respectively).

Survey biomass indices of legal-sized males

Biomass estimates are interpreted qualitatively because they do not account for the overall low catchability of snow crabs by the survey trawl or the effects of substrate type and crab size on catchability (Dawe et al. 2002). Survey biomass indices for legal-sized males (Fig. 10) are considered to represent residual (post-fishery) biomass levels, although a small proportion of the annual catch was taken during the October-December survey period in some years.

The residual biomass index for Div. 2J3KLNO legal-sized crabs (Fig. 10) in 2001, (44,475 t) was 13% higher than in 2000 (39,461 t) and 6% lower than in 1999 (47,140 t). This post-fishery biomass index had been relatively stable during 1996-1998, at about 73,000-86,000 t before dropping by 45% in 1999. The 2000 mean estimate was about 48% lower than that of 1998.

It has previously been noted (Dawe et al. 2001) that within Div. 2J3KL the fall residual biomass index peaked progressively later from south to north; in 1996 in Div. 3L, in 1997 in Div. 3K, and in 1998 in Div. 2J. Decreases were evident throughout Div. 2J3KL in 1999 (Fig. 10), and the magnitude of these decreases was greater in Div. 2J (58%) and Div. 3K (59%) than in Div. 3L (42%). These estimates further decreased in 2000 in Div. 2J (by 41%) and in Div. 3L (by 26%), with the magnitude of the decrease again being greater in the more northern division. However

the biomass index increased by 55% in Div. 3K over the past two years, following a 59% decrease in 2000. It is presently uncertain whether this sharp division-specific change reflects change in biomass or area-specific annual changes in catchability of legal-sized crabs by the survey trawl.

Male size composition

Male size distributions from Div. 2J3KLNO fall surveys reflect the stable commercial (>94 mm) biomass levels during 1996-98, the decrease in 1999, and the relatively stable biomass at a lower level since then (Fig. 11). They also reflect a lower biomass of sublegal-sized (76-94 mm CW) adolescents during 1999-2001 than during 1995-1998.

A 'trough' evident at about 40-75 mm CW throughout 1996-2000 persisted in 2001, perhaps reflecting low catchability of this size group. Such low catchability is likely related to distribution, especially with respect to substrate type, for this size range. For example, catchability of this size group may be low on rough shallow-water strata, where the trawl may not maintain constant contact with the bottom. The biomass index for this size group is currently considered to be unreliable for indicating future recruitment trends.

Abundance of smallest males (<40 mm) increased markedly in 2000, following a regular decline throughout 1995-1999 (Fig. 11). It has been noted that changes in abundance at such small sizes are not directly related to the fishery, but likely involve a complex interaction of factors that may include bitter crab disease, density-dependent processes, and environmental effects (Dawe et al 2001, Dawe 2002, Dawe and Colbourne 2002). Such effects are further confounded by the very low catchability of smallest crabs by the survey trawl, especially on hard substrates (Dawe et al 2002).

Trends in male size frequency distributions in recent years have varied considerably among divisions (Fig. 12). Greatest differences have been in the apparent abundance of smallest males (smaller than about 40 mm), that increased greatly in both Div. 2J and Div. 3K in 2000, while decreasing in Div. 3L. These smallest males continued to increase in 2001 in Div. 2J3K, but also increased in Div. 3L. Smallest males in Div. 3L increased in 1999 but then decreased in 2000 before increasing markedly in 2001 (Fig. 12). Size distributions for Div. 3NO (Fig. 12) continue to show no clear trends and cannot reliably be interpreted because of the unsuitability of the sampling regime for the highly aggregated resource in this area. However, abundance of smallest (<40 mm) males, relative to larger males, appears to remain very low in Div. 3NO, relative to 1995-1996 levels as well as to the recent levels in the more northern divisions. The unclear trends in smallest males are likely related to their low and variable catchability by the survey trawl, which, together with the observed high spatial variability, leads to considerable uncertainty.

To facilitate spatial comparison of abundance trends of larger males within Div. 2J3KL we compared the divisional size frequency distributions for only those males larger than 52 mm. (Fig. 13). Clear trends were evident, including a decrease across all three divisions, and all sizes, in 1999. Also, it is clear that this index remained low for those males larger than about 80 mm CW during 2000-2001 in for both Div. 2J and Div. 3L. In striking contrast, abundance indices increased greatly across all sizes in Div. 3K in 2000 and then decreased in 2001, but remained higher than 1999 levels. These sharp annual changes in Div. 3K occurred across the full size range and were generally most pronounced in smallest crabs. They reflect 'year effects' that are very likely related to substantial changes in catchability of crabs by the survey trawl that could be due to several factors including annual changes in distribution with respect to substrate type (Dawe et al. 2002). There is some suggestion of a slight overall increase in abundance indices of males of about 53-80 mm CW since 1999 in Div 2J3KL (Fig. 13). However, as noted

above, indices for this size range are currently considered unreliable and a longer time series will be required to clarify possible recent trends and their implications for future recruitment.

Mean size of legal-sized males

The mean size of legal-sized males reflects the interacting and generally opposing effects of removals by the fishery and annual entry of new-shelled prerecruits to legal size. Annual trends in mean size of legal-sized males have been associated with changes in abundance and recruitment (DFO 2002). Decreasing mean size may reflect annually increasing abundance of small legal-sized prerecruits relative to fully recruited adults, whereas increasing mean size may reflect a period of declining recruitment.

Mean size of legal-sized males in our fall surveys s' ow some clear spatial and annual trends (Table 3, Fig. 14). Mean CW has been consistently smallest and least variable in Div. 3L, where it ranged between 104.4-106.3. This implies that recruitment relative to the exploitable biomass may be higher in Div. 3L than in the other divisions. An increase in mean CW was evident throughout the time series in the southern portion of the survey area (Div. 3LNO), especially on the southern Grand Bank (Div. 3NO). Mean CW increased by about 7 mm between 1995 and 2001 in both Div. 3N and Div. 3O. One interpretation of this increase is that recruitment has been declining in the South. Mean size across years was overall largest in 1999 in the northern areas (Div. 2J3KL), where it decreased in 2000 and increased in 2001 (Table 3, Fig. 14). This trend is consistent with the substantial decrease in new-shelled relative to older-shelled legal-sized males in 1999 (Fig.9), that was clearer in Div. 2J3K than in Div. 3L.

Projected exploitable biomass and recruitment

Projections based on the 1995-2001 fall survey data (Table 4, Fig. 15) indicate that the exploitable biomass index for 2002 (38,355 t) was about 28% higher than that for the previous year (29,969 t) but about 8% lower than that for 2000 (41,553 t). Generally then, the exploitable biomass has remained stable over the most recent three years following a 42% drop in 2000 (Fig. 15).

The biomass index of prerecruits projected for 2002 was about 10% lower than that for the previous year and about 13% lower than that for 2000 (Table 5, Fig. 15). This relative stability during the most recent three years followed a steady overall decline of 57% during 1997-2000.

The projected prerecruit indices were more precisely estimated for 2001 and 2002, than for 1997-1999, as reflected by differences in the distribution of 95% confidence intervals about the means (Fig.15, Table 5). The exploitable biomass indices were generally more precisely estimated than were the prerecruit indices. We feel there is higher uncertainty associated with the projected prerecruit indices than with the exploitable biomass indices. This difference in uncertainty is not only due to differences in precision of estimates but is primarily related to differences in molt status between the two groups. The exploitable biomass index is comprised exclusively of males that were terminally-molted adults in the preceding fall survey, whereas the prerecruit index includes a large component of males that were adolescents as small as 76 mm CW during the preceeding survey. The projection of the prerecruit index assumes that all those adolescents will molt, survive, grow by 19 mm CW and subsequently recruit (over the following two years, involving yet an additional molt for those that remained legal-sized adolescents), as older-shelled males. In reality, the biomass of new-shelled prerecruit crabs is greatly affected by annual variability in natural mortality, growth increment and proportions that fail to molt. These variables currently cannot be predicted and so are not accounted for in the projections.

Annual divisional indices were more imprecise and uncertain than those for the entire survey area. Confidence intervals about divisional means were much broader than those for the entire survey area (Table 4 and 5). This was especially true for Div. 3NO indices, which also exhibited unrealistic annual changes in mean values and so are considered unreliable. Most year-to-year changes in divisional indices for Div. 2J3KL cannot be reliably interpreted because of considerable overlap of the relatively broad confidence intervals (Table 4 and 5), but longer-term trends and divisional differences may be insightful (Fig. 15).

The exploitable biomass index increased initially in all three divisions and peaked progressively later from south to north, between 1997 in Div. 3L to 1999 in Div. 2J. This index declined steadily in Div. 3L, by 72 % during 1997-2001, whereas it declined sharply in 2000 in both Div. 2J (by 53 %) and Div. 3K (by 55 %). These projected divisional indices have changed little between 2001 and 2002, having decreased by 9 % in Div 2J and increased by 16 % and 20 % in Div. 3K and Div. 3L respectively. These changes in 2002 are not significant when considered in relation to the confidence limits about the means as well as uncertainties associated with variation in catchability by the survey trawl. Exploitable biomass indices increased from north to south during 1996-2000, whereas those for the past two years have been similar between Div. 3K and Div. 3L (Fig. 15).

Trends in prerecruit biomass indices were generally similar to trends in exploitable biomass indices, with highest indices for Div. 3L and lowest indices for Div. 2J (Fig. 15). The progressively later peaks from south to north in exploitable biomass indices were also seen in prerecruit indices, which peaked in 1997 in Div. 3L, in 1998 in Div. 3K and in 1999 in Div. 2J. Prerecruit indices for all three divisions (Div. 2J3KL) declined until 2000, whereas exploitable biomass indices continued to decline until 2001 in both Div. 2J and Div. 3L. Prerecruit indices were highest in Div. 3L during 1996-1998, whereas they were highest in Div. 3K during 2001-2002.

Ratio of catch to exploitable biomass index

The ratio of catch to the exploitable biomass index does not estimate absolute exploitation rate, because catchability of the survey trawl is less than 1, so exploitable biomass is underestimated and, consequently exploitation rate is overestimated by this ratio. However long-term changes in this ratio may be interpreted as reflecting trends in exploitation rate. This ratio, for the entire survey area (Fig.16), decreased by 26 % in 1997 and has increased steadily since then, by 180 % over the past four years. The increase above 1.0, to 1.57 in 2001 clearly indicates that this ratio greatly underestimates exploitation rate.

Divisional ratios for Div. 2J3KL (Fig. 16) were highest in 1996 in Div. 2J but became highest in Div. 3L in 2001. They have increased since 1997 in Div. 3KL and since 1998 in Div. 2J. This ratio did not change in Div. 3K in 2001 whereas it continued to increase in both Div. 2J and Div. 3L. The increase in Div. 3L was quite sharp, as it more than tripled between 1997 and 2001. It doubled from 1.23 in 2000 to 2.49 in 2001. This unrealistically high 2001 value for Div. 3L further reflects the low catchability of legal-sized crabs by the survey trawl. It is quite possible that catchability differs among divisions due to spatial differences in substrate type.

This index of relative exploitation rate does not account for removals that are not included in the commercial catch. The discard mortality rate has not been quantified but it is probably substantial and would likely increase as biomass declines. Timely application of proper handling and discarding practices would minimize mortality on discarded prerecruit males and soft-shelled legal-sized males as well as small legal-sized males of relatively low commercial value.

Bitter crab disease (BCD)

BCD has been observed, based on macroscopic observations, at low levels throughout 1996-2001 (Fig. 17); data were not collected in 1995, the first multispecies survey year. The prevalence and distribution of this parasitic disease throughout the Newfoundland-southern Labrador Continental Shelf (Div. 2J3KLNO) has been described in detail by Dawe (2002). Prevalence and distribution of BCD in recently-molted males during fall 2001 were similar to those in other years in that prevalence was overall low but was highest in intermediate-sized males. It was recognized in 3.3 % and 3.6 % of 41-59 mm CW recently-molted males in Div. 3K and Div. 3L, respectively, in 2001. Also consistent with other years, it was not observed in most-southern Div. 3NO in 2001. Prevalence in 2001 was changed little from the previous year, remaining low relative to 1997. BCD appears to have extended southward over the past three years (Fig. 18) with highest prevalence having moved from Div. 2J in 1999, to Div. 3K in 2000, and having increased substantially in Div. 3L in 2001 to a level similar to that in Div. 3K. This increase in Div. 3L in 2001 was coincident with a great increase in survey catch rates of smallest males (Fig. 12). BCD was mostly confined to the three northeast coast bays of Div. 3L in 2000 (Fig. 18). While it was observed in all sets within those bays in 2001, it also occurred in many offshore sets, extending across the northern Grand Bank.

BCD occurs in both sexes and all sizes of snow crab. Its prevalence in mature females is comparable to that in comparably-sized males (Dawe 2002). It is unknown how well disease prevalence in trawl-caught samples, especially based on recognition of external characteristics in chronic cases, represents true prevalence in the population, but it seems likely that our observations underestimate true prevalence. Relationships of prevalence with density are unclear (Dawe 2002) and implications for mortality are unknown.

Reproductive Biology

The abundance indices of mature females declined sharply across the entire fall survey area during 1995-1997, and has remained low during 1998-2001 (Fig. 19). While this may imply some concern for egg production, the decline in abundance was much sharper in mature females than in largest (legal-sized) adult males (Fig. 19). Of the legal-sized adult males and mature females, the sex ratio continued to strongly favor males in 2001 (excepting Div. 3K), as has generally been the case throughout the survey series. This implies no decrease in mating success of females. This is supported by the consistently high proportion of mature females bearing full clutches of viable eggs over the time series (Fig. 19). In fact, even in those few cases where sex ratios favored females (Div. 3KL in 1995 and Div. 3K in 2000 and 2001) almost 100% of the mature females were carrying full clutches of viable eggs. The percent of females with full clutches was low in 2001 in Div. 3L (51%), but this was associated with a sex ratio that favored males (64% males).

Comparison of Fishery and Survey Trends

Annual trends in Div. 2J3KL commercial CPUE and survey-based exploitable biomass indices were most similar in Div. 2J and most dissimilar in Div. 3L (Fig. 20). These indices were strongly positively related in Div. 2J (r^2=0.78), were positively but not as strongly related in Div. 3K (r^2=0.33), and were negatively related in Div. 3L (r^2=0.64). This change from a direct to an inverse relationship from north to south appears to be associated with north-south differences in snow crab habitat (bottom topography and substrate type) and in the relationship of fishing effort distribution with distribution of the resource. Highest survey catch rates of legal-sized males have generally occurred in deep (300-500 m) channels with soft substrates in the northern divisions (Div. 2J3K), whereas they have occurred across the northern and eastern

slopes of the Grand Bank (at 50-1200 m depths) in Div. 3L (Fig. 7a and 8). The extent to which fishing depths have reflected the depth distribution of the resource (according to surveys) has been greatest in Div. 2J and smallest in Div. 3L (Fig. 8 and 21).

The lack of a direct relationship between survey and fishery indices in Div. 3L may be, in part, due to retraction of the resource from depths exceeding those commercially fished as resource biomass declined, thereby moderating the decline in density in shallow fishing depths. Fishing effort has shifted slightly but steadily from 200-400 m to the 100-200 m depth range in Div. 3L during 1996-2001 (Fig. 21), supporting the apparent retraction from greater depths (Fig. 8).

While the spatial variation and annual changes in the depth distribution of the resource relative to the fishery may account for the progressive deterioration of direct relationships between fishery and survey indices from north to south, they do not account for the inverse relationship that was evident for Div. 3L (Fig. 20). The increase in CPUE since 1997 was not consistent with declining survey catch rates within commercial fishing depths (100-200 m, Fig. 8). This inconsistency could relate to problems with both the fishery and the survey data series. The fishery data are unstandardized for effects of annual changes in fishing practices, and the survey series does not account for strong effects of crab size and substrate type on catchability by the survey trawl.

Despite this conflict between fishery and survey indices in Div. 3L, there is a high level of agreement among catch rate and biological indices from the surveys that suggest recent declining recruitment. The decline in survey catch rates of legal-sized males across all depths in Div. 3L over the survey series is associated with contraction of the resource, increase in mean size of legal-sized males, and a decline in the catch rate of new-shelled relative to older-shelled legal-sized males.

Other Considerations

Cannibalism on settling year classes has been identified as a possible density-dependent mechanism which could maintain an intrinsic oscillation in recruitment (Sainte-Marie et al. 1996, Lovrich and Sainte-Marie 1997). Until recently, it has been unknown how important cannibalism may be as a source of mortality because there have been no data on snow crab diet specific to this area. However recent stomach contents analysis indicates that cannibalism was prevalent in Div. 3K in fall 2000 (Fig. 22), across a broad size range. About 10-15 % of crabs within the 40-100 mm CW size range had recently cannibalized smaller crabs.

Changes in abundance of smallest crabs may be also be related to density-independent effects, such as environmental changes. Colbourne (2001) has shown that Div. 3L CPUE is significantly inversely related to temperature indices, with an 8-year lag, implying an effect early in the life cycle. Environmental variation may affect distribution, behavior, growth, and catchability but it is unclear how it may affect the various life-history stages and subsequently impact recruitment. Although cold conditions are believed to be favorable to planktonic larval or early benthic stages, there is considerable uncertainty regarding effects of warming, since 1995 (Colbourne 2002). Although this warming implies an adverse effect on recruitment in the very near future, we recognize that there have been major ecosystem changes in the late 1980's-early-1990's, including a great decline in abundance of predatory groundfishes. Consequently, it is quite possible that environmental effects of the past may be no longer applicable.

References

Colbourne, E. 2002. Physical Oceanographic conditions on the Newfoundland and Labrador Shelves during 2001. CSAS Res. Doc. 23/02.

Dawe, E. G. 2002. Trends in Prevalence of Bitter Crab Disease Caused by *Hematodinium* sp. in Snow Crab (*Chionoecetes opilio*) throughout the Newfoundland and Labrador Continental Shelf. pp. 385-400 *In*: Crabs in Cold Water Regions: Biology, Management, and Economics. Edited by A.J. Paul, E.G. Dawe, R. Elner, G.S. Jamieson, G.H. Kruse, R.S. Otto, B. Sainte-Marie, T.C. Shirley, and D. Woodby University of Alaska Sea Grant, AK-SG-02-01, Fairbanks, 786 pp.

Dawe, E.G., and E.B. Colbourne. 2002. Distribution and demography of snow crab(*Chionoecetes opilio*) males on the Newfoundland and Labrador shelf. pp. 577-594 *In*: Crabs in Cold Water Regions: Biology, Management, and Economics. Edited by A.J. Paul, E.G. Dawe, R. Elner, G.S. Jamieson, G.H. Kruse, R.S. Otto, B. Sainte-Marie, T.C. Shirley, and D. Woodby University of Alaska Sea Grant,AK-SG-02-01, Fairbanks, 876 p.

Dawe, E.G., H.J. Drew, P.C. Beck, P.J. Veitch, R.T. Warren, and R.L. Costigan. 2001. An assessment of Newfoundland and Labrador snow crab in 2000. CSAS Res. Doc. 2001/087, 27 p.

Dawe, E. G., B. R. McCallum, S. J. Walsh, P. C. Beck, H. J. Drew and E. M Seward. 2002. A study of the catchability of snow crab by the Campelen 1800 survey trawl. CSAS Res. Doc. 51/02.

DFO, 2002. Snow crab of the Estuary and Northern Gulf of St. Lawrence (Areas 13 to 17). DFO Science Stock Status Report C4-01 (2002), 13 p.

Hoenig, J.M., E.G. Dawe, and P.G. O'Keefe. 1994. Molt indicators and growth per molt for male snow crabs (Chionoecetes opilio). J. Crust. Biol. 14(2): 273-279.

Lovrich, G. A., and B. Sainte-Marie. 1997. Cannibalism in the snow crab, Chionoecetes opilio (O. Fabricus) (Brachyura: Majidae), and its potential importance to recruitment. J. Exp. Mar. Biol. Ecol. 211: 225-245.

Moriyasu, M., G.Y. Conan, P. Mallet, Y.J. Chiasson, and H. Lacroix. 1987. Growth at molt, molting season and mating of snow crab (Chionoecetes opilio) in relation to functional and morphometric maturity. ICES C.M. 1987/K:21, p. 1-44.

Sainte-Marie, B., S. Raymond, and J.-C. Brêthes. 1995. Growth and maturation of the benthic stages of male snow crab, Chionoecetes opilio (Brachyura, Majidae). Can. J. Fish. Aquat. Sci. 52: pp. 903-924.

Sainte-Marie, B., J-M. Sévigny, B. D. Smith, and G. A. Lovrich. 1996. Recruitment variability in snow crab Chionoecetes opilio: pattern, possible causes, and implications for fishery management. pp. 451-478 *In*: Proceedings of the International Symposium on the Biology, Management, and Economics of Crabs from High Latitude Habitats. Edited by B. Baxter, Lowell Wakefield Fish. Symp. Ser., Alaska Sea Grant Rep. No. 96-02, 713 p.

Smith, S.J., and G.D. Somerton. 1981. STRAP: A user-oriented computer analysis system for groundfish research trawl survey data. Can. Tech. Rep. Fish. Aquat. Sci. 1030: 66 p.

Taylor, D.M., and J.M. Hoenig. 1990. Growth per molt of male snow crab, Chionoecetes opilio, from Conception and Bonavista Bays, Newfoundland. Fish Bull., United States. 88: 753-760.

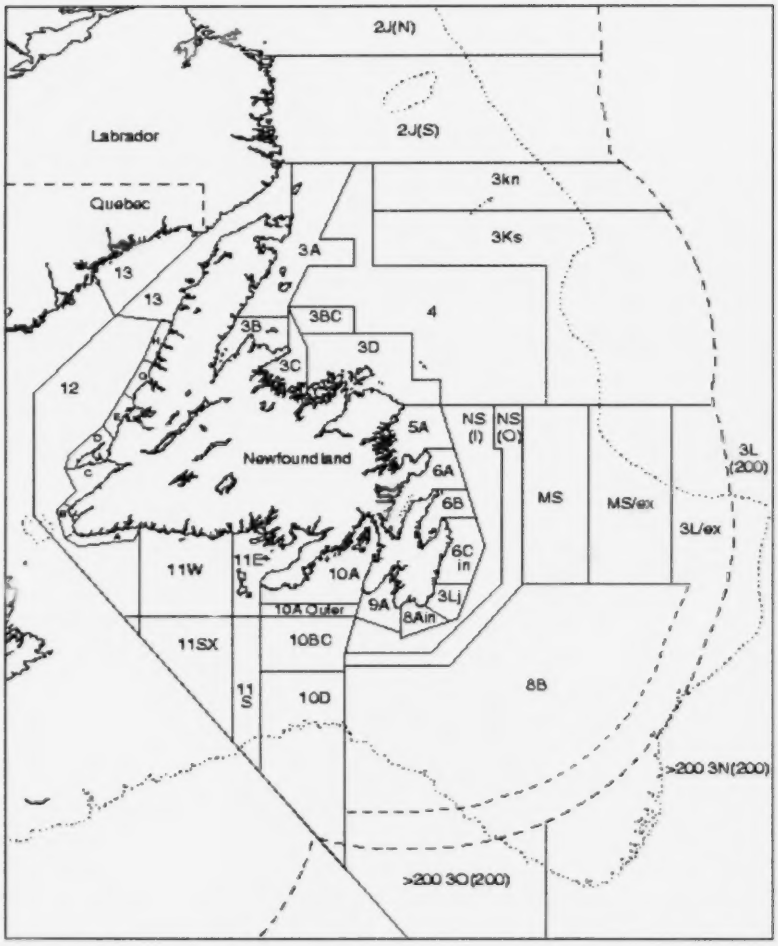

Figure 1: Snow crab management areas for 2001.

Table 1. Catches and TAC's (t) by year and NAFO Division for 1999-2001.

Division	1999 TAC (Catch)	2000 TAC (Catch)	2001 TAC (Catch)
2J	4455 (5448)	3411 (3794)	3340 (3756)
3K	18200 (21359)	13493 (15431)	13693 (15277)
3L	26250 (27955)	22710 (23975)	23655 (25191)
3NO	3250 (4759)	2425 (2882)	2425 (2963)
2J3KLNO	**52155 (59521)**	**42039 (46082)**	**43113 (47187)**
3Ps	7700 (7903)	7700 (7917)	7600 (7843)
4R	1330 (1612)	1430 (1640)	1539 (1675)
All Divisions	**61185 (69036)**	**51169 (55639)**	**52252 (56705)**

Table 2. Annual catch (t, *italicized*), effort (trap hauls x 1000, underlined), and CPUE (kg/trap haul) by Division for the period 1996-2001.

Division	1996	1997	1998	1999	2000	2001
2J	*3090*	*3166*	*4081*	*5448*	*3794*	3756
	302	266	281	391	296	426
	10.2	11.9	14.5	13.9	12.8	8.8
3K	*14190*	*14830*	*16813*	*21359*	*15431*	15277
	1163	1256	1184	1593	1264	1364
	12.2	11.8	14.2	13.4	12.2	11.2
3L	*16071*	*20930*	*22471*	*27955*	*23975*	25191
	1078	1414	1440	1644	1261	1325
	14.9	14.8	15.6	17	19	19
3NO	*776*	*1255*	*1559*	*4759*	*2882*	2963
	74	82	79	232	141	139
	10.4	15.3	19.7	20.5	20.4	21.2
2J3KLNO	***34127***	***40181***	***44924***	***59521***	***46082***	**47187**
	2617	**3018**	**2984**	**3860**	**2962**	**3254**
	13	**13.3**	**15.1**	**15.4**	**15.6**	**14.5**
3Ps	*3047*	*4753*	*6614*	*7903*	*7917*	*7843*
	183	235	319	337	386	499
	16.6	20.2	20.7	23.4	20.5	15.7
4R	*833*	*969*	*1063*	*1612*	*1640*	*1675*
	141	269	212	366	321	328
	5.9	3.6	5	4.4	5.1	5.1
All Divisions	***38007***	***45903***	***52601***	***69036***	***55639***	**56705**
	2941	**3522**	**3515**	**4563**	**3669**	**4081**
	12.9	**13**	**15**	**15.1**	**15.2**	**13.9**

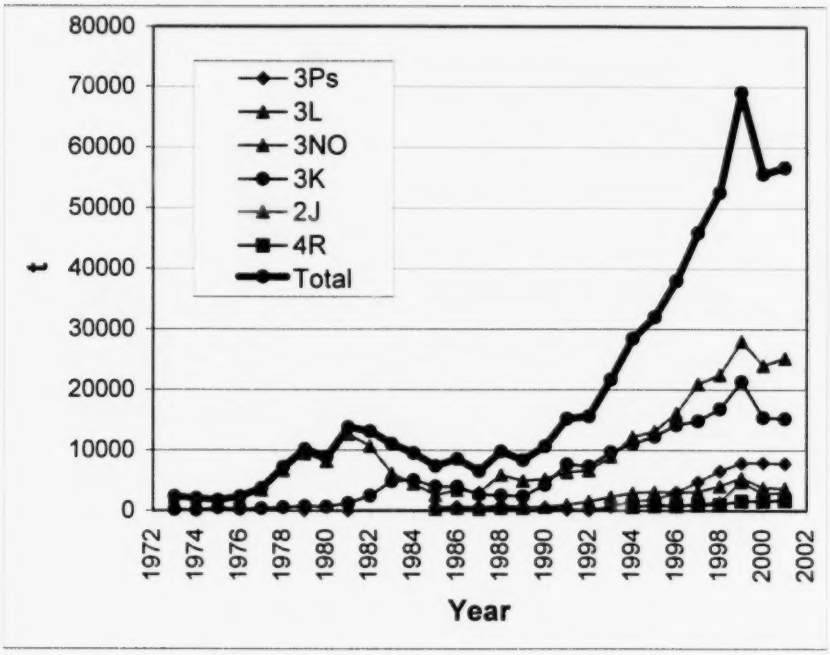

Figure 2: Annual landings by NAFO Division, 1973-2001

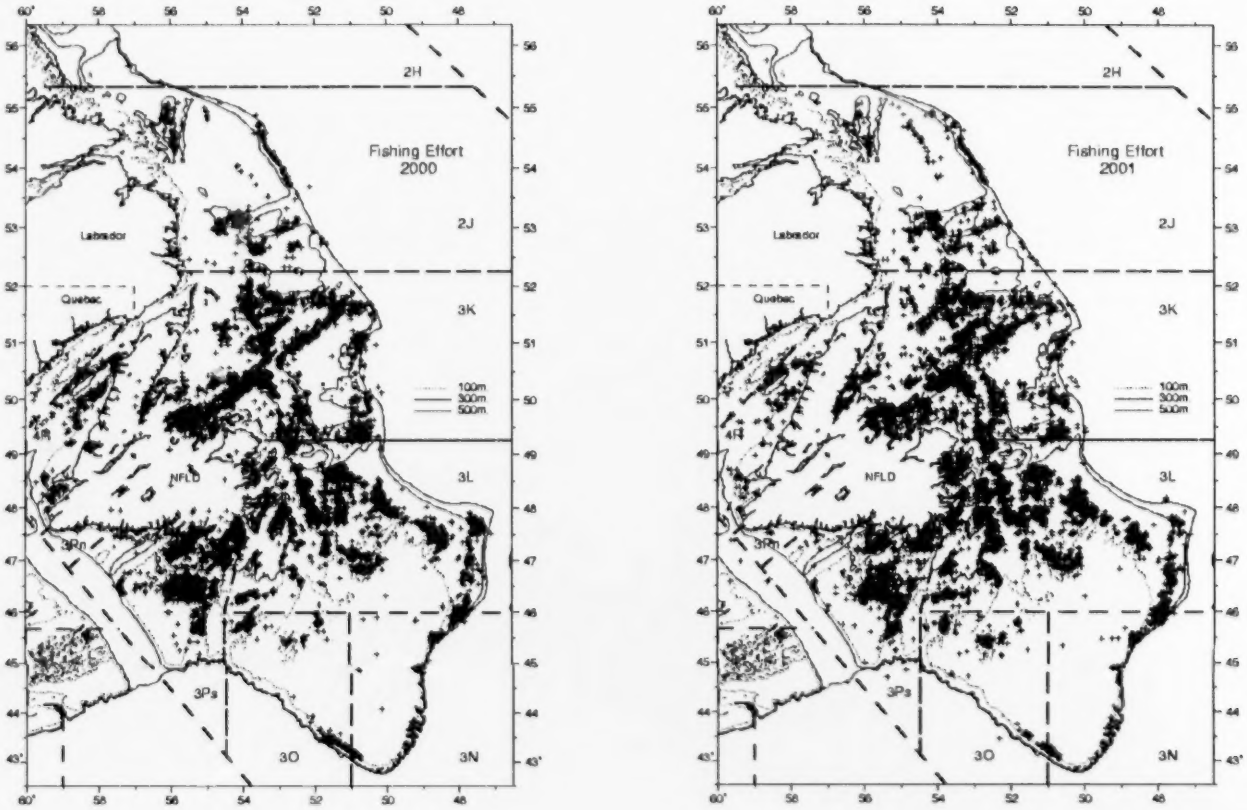

Figure 3: Distribution of primarily offshore commercial fishing effort in 2000 and of inshore and offshore effort in 2001.

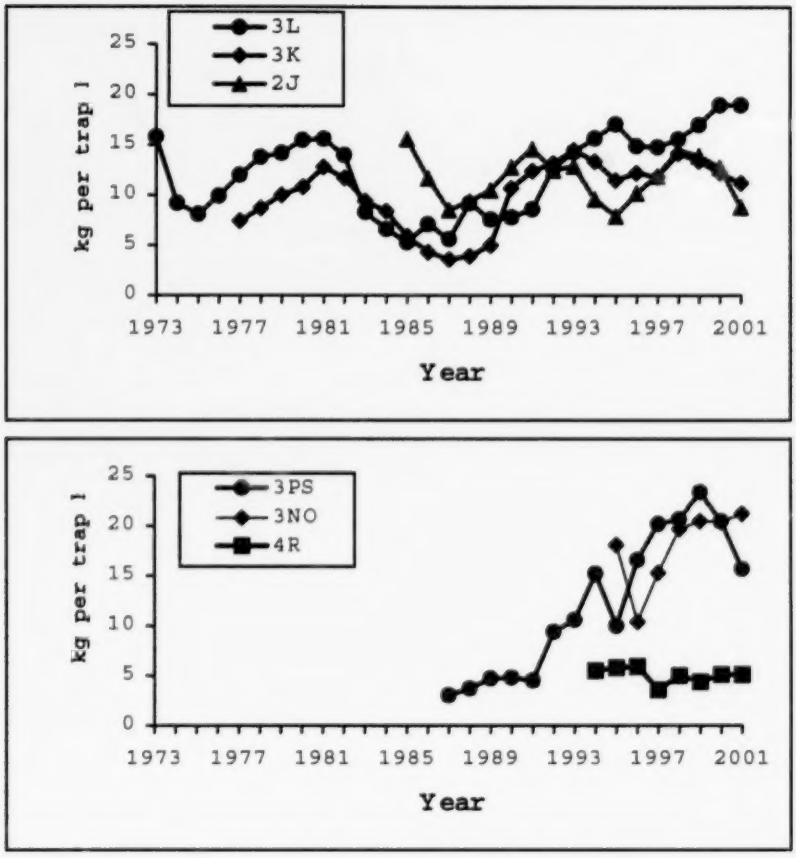

Figure 4: Annual trend in CPUE by NAFO Division

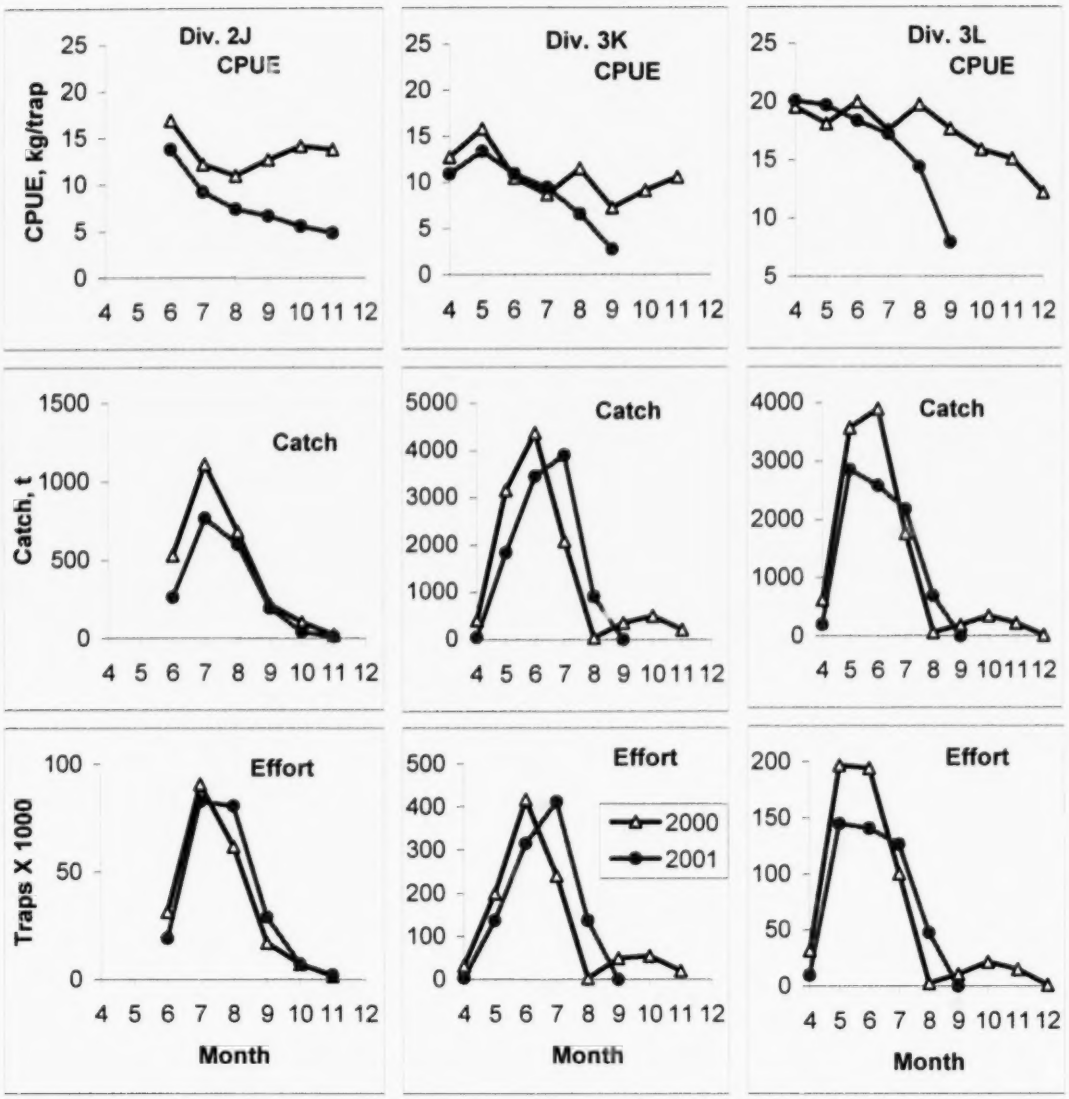

Figure 5: Seasonal trends in catch, effort and CPUE in 2000 and 2001 for Divisions 2J, 3K and 3L.

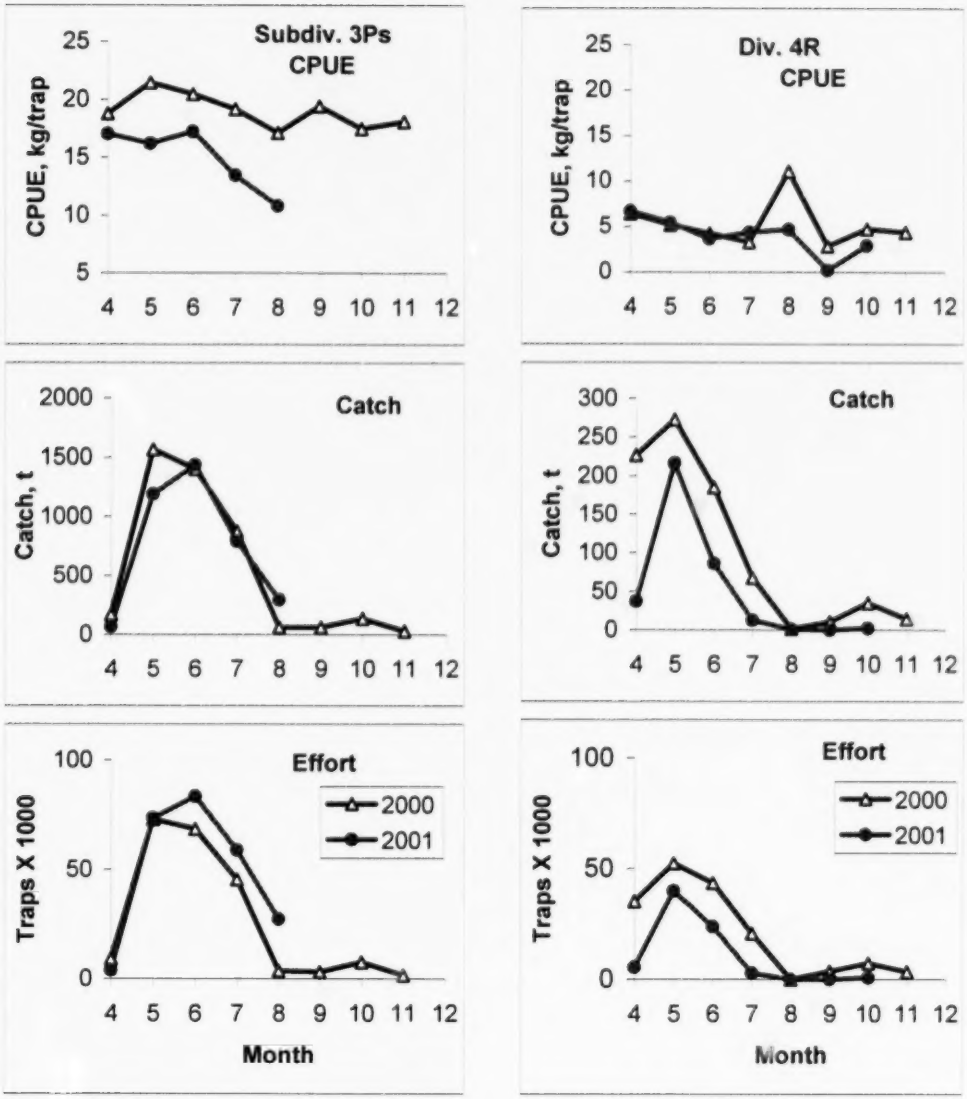

Figure 6: Seasonal trends in catch, effort and CPUE in 2000 and 2001 for Subdivision 3Ps and Division 4R.

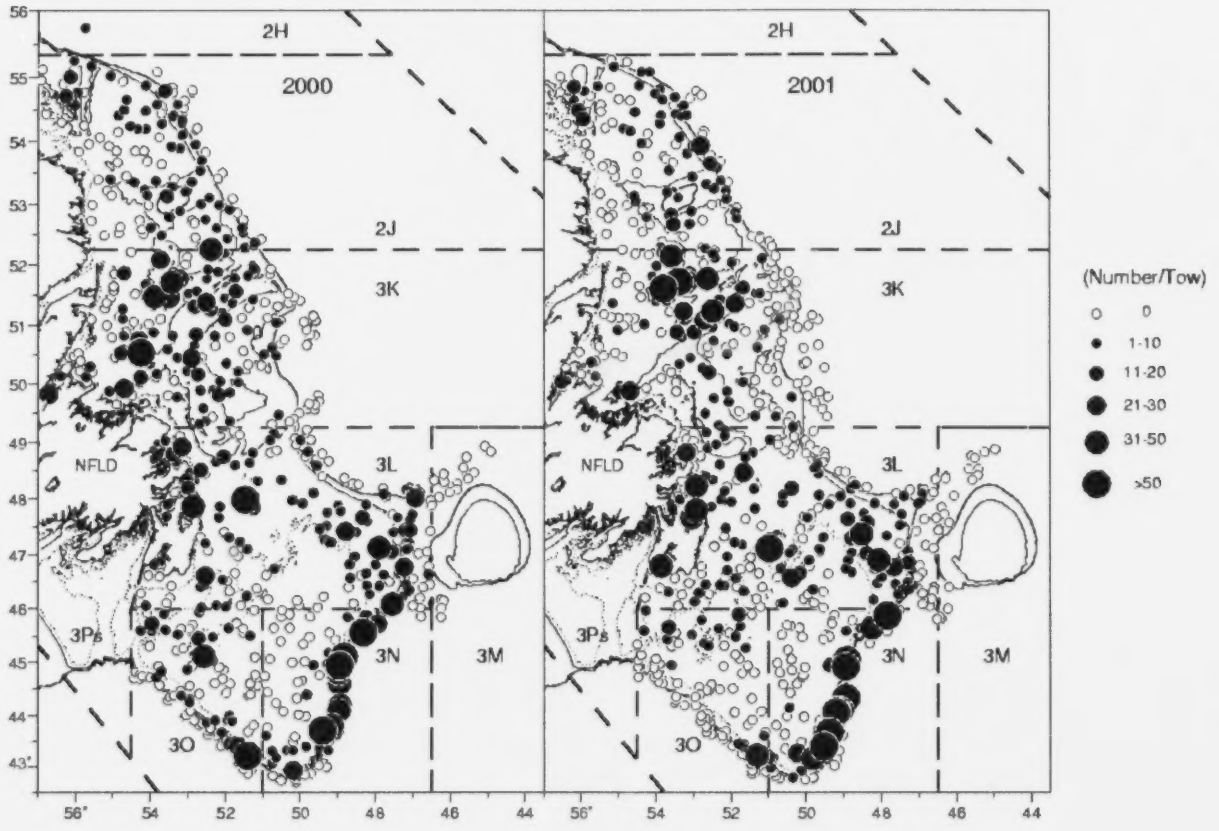

Figure 7a: Distribution of legal-sized males (>94 mm CW) from fall Div. 2J3KLNO multispecies bottom trawl surveys in 2000 and 2001.

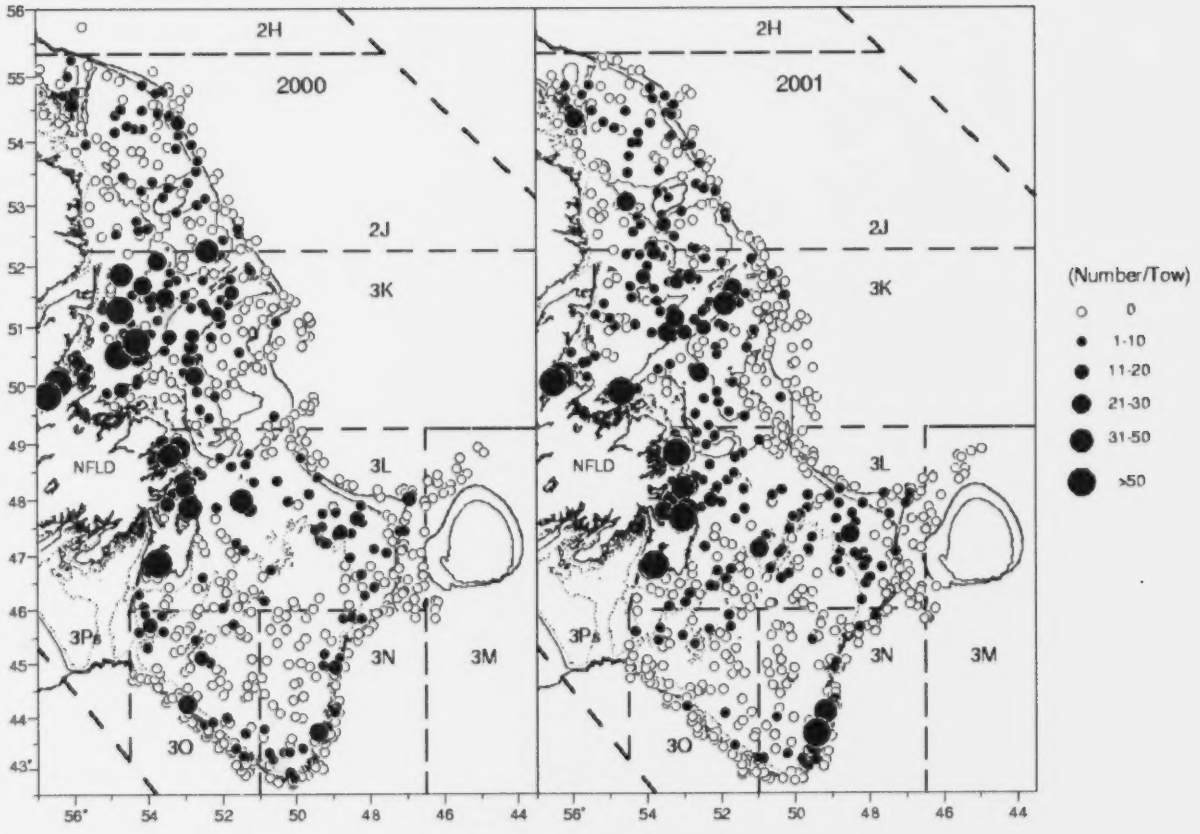

Figure 7b: Distribution of Sublegal 1 males (76-94 mm CW) from fall Div. 2J3KLNO multispecies bottom trawl surveys in 2000 and 2001.

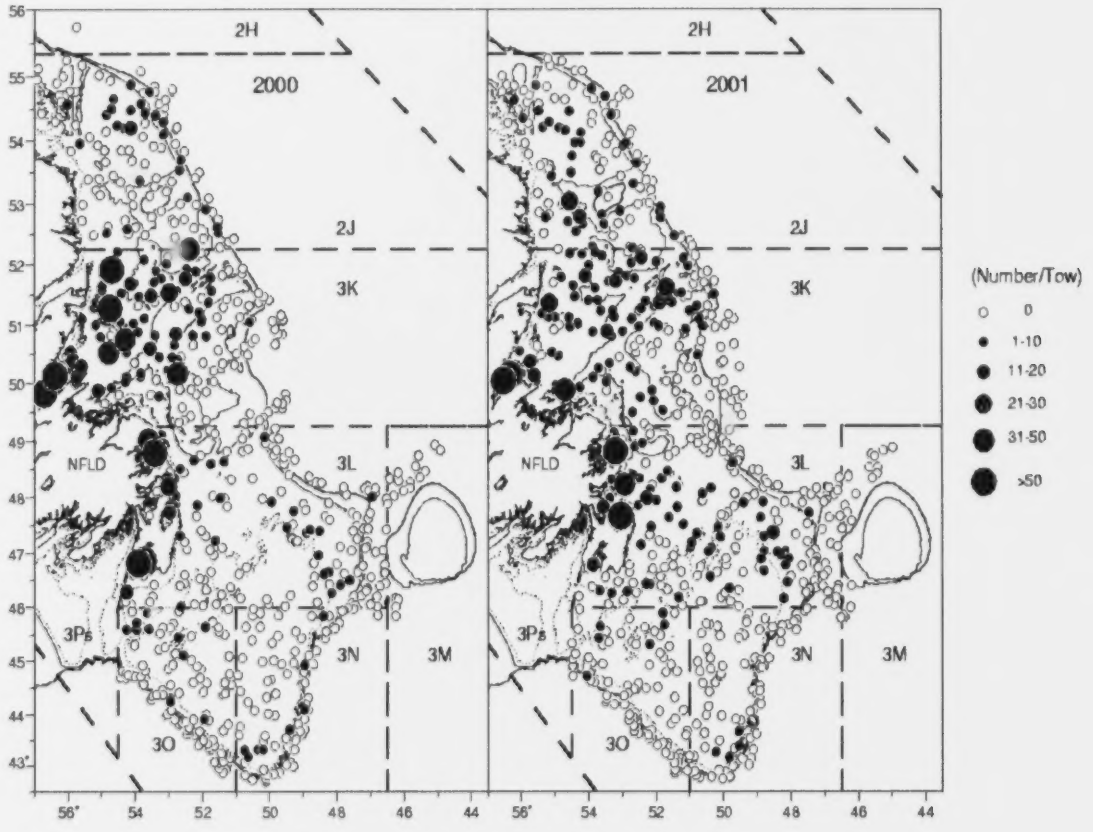

Figure 7c: Distribution of Sublegal 2 males (60-75 mm CW) from fall Div. 2J3KLNO multispecies bottom trawl surveys in 2000 and 2001.

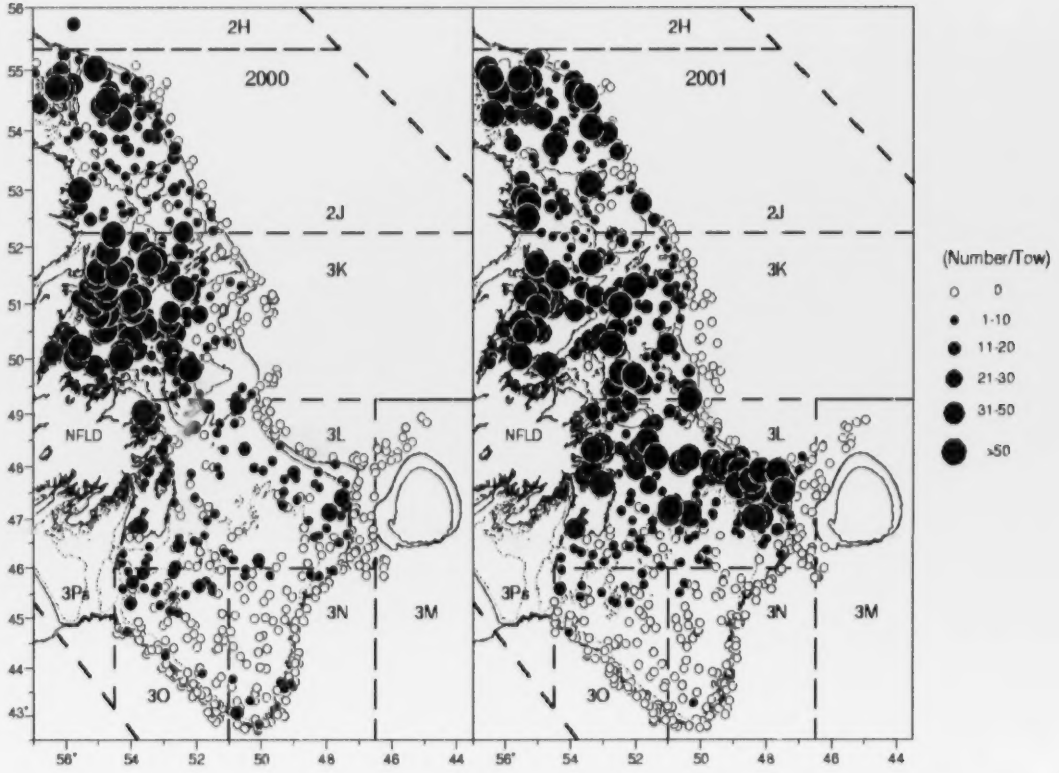

Figure 7d: Distribution of smallest males (<60 mm CW) from fall Div. 2J3KLNO multispecies bottom trawl surveys in 2000 and 2001.

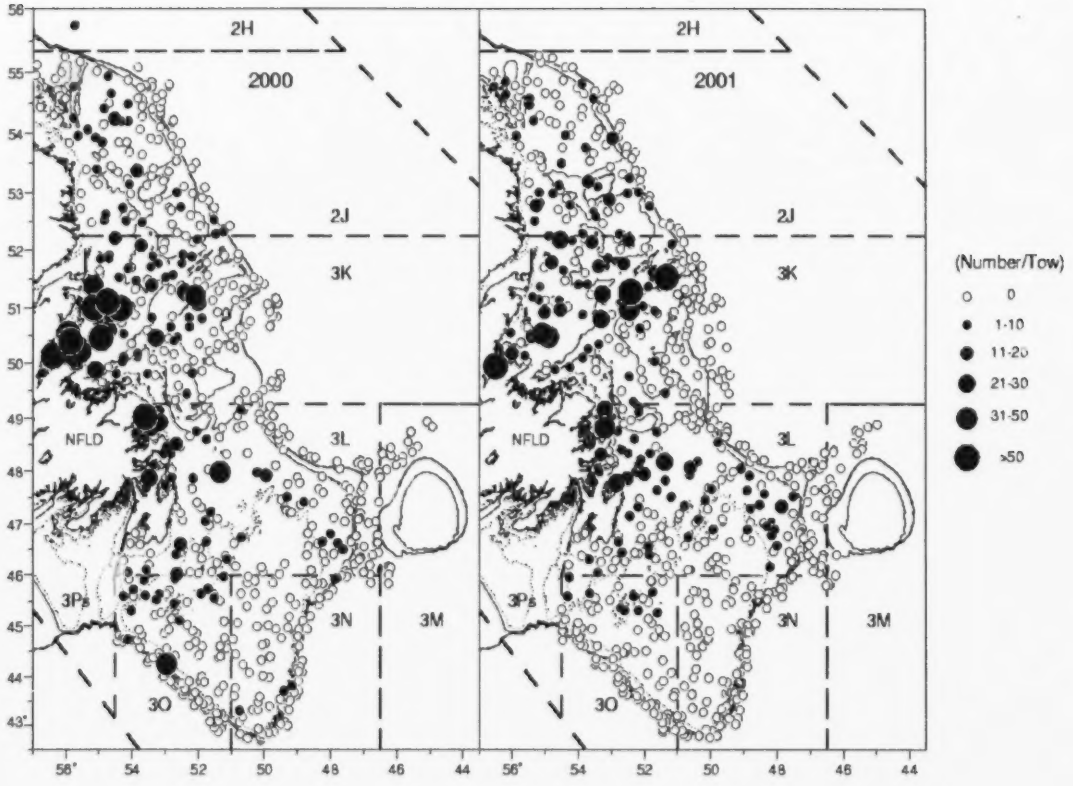

Figure 7e: Distribution of mature females from fall Div. 2J3KLNO multispecies bottom trawl surveys in 2000 and 2001.

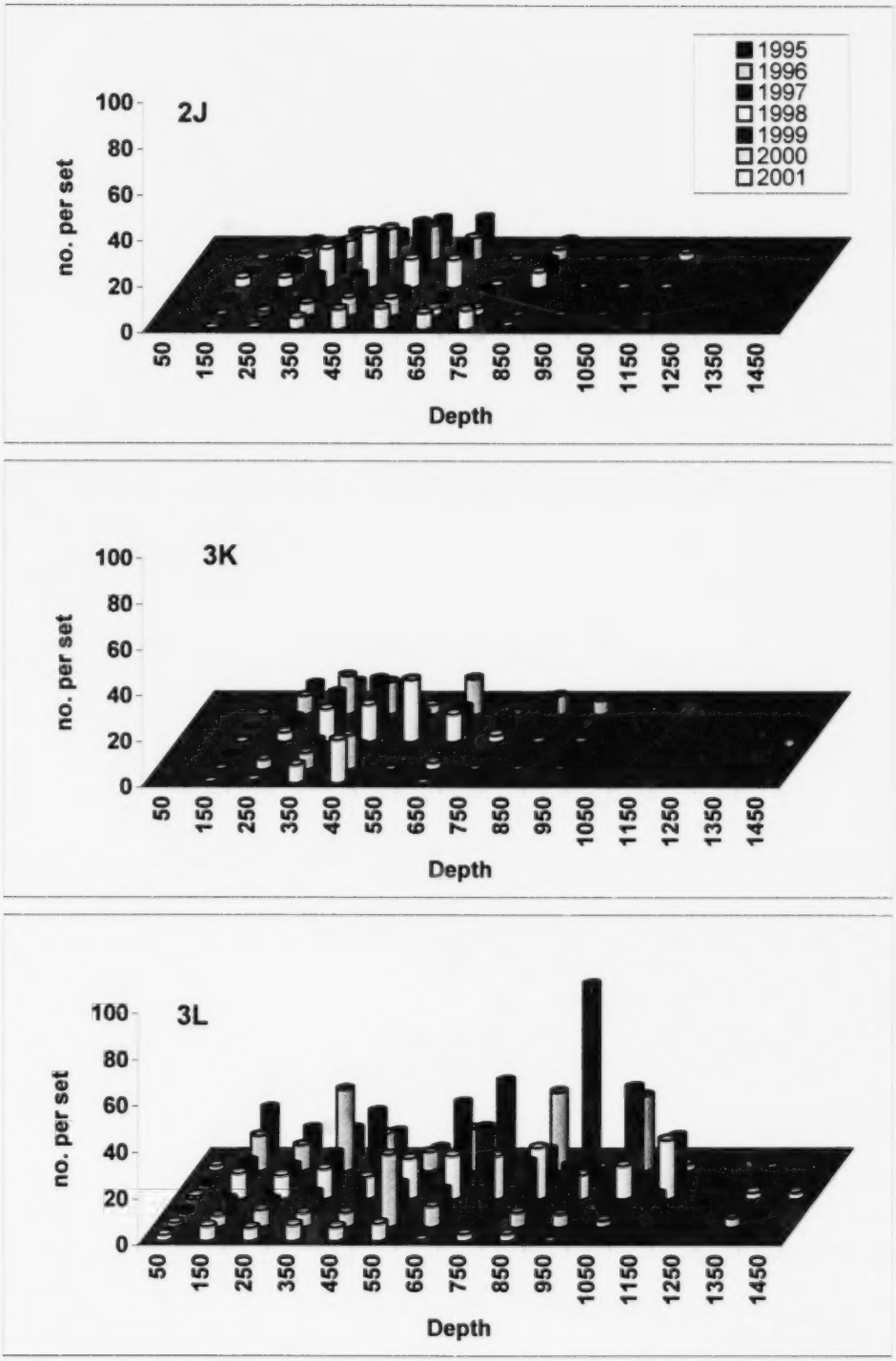

Figure 8: Annual trends in fall survey catch rates of legal-sized males by 100 m depth interval for Div. 2J, 3K, and 3L.

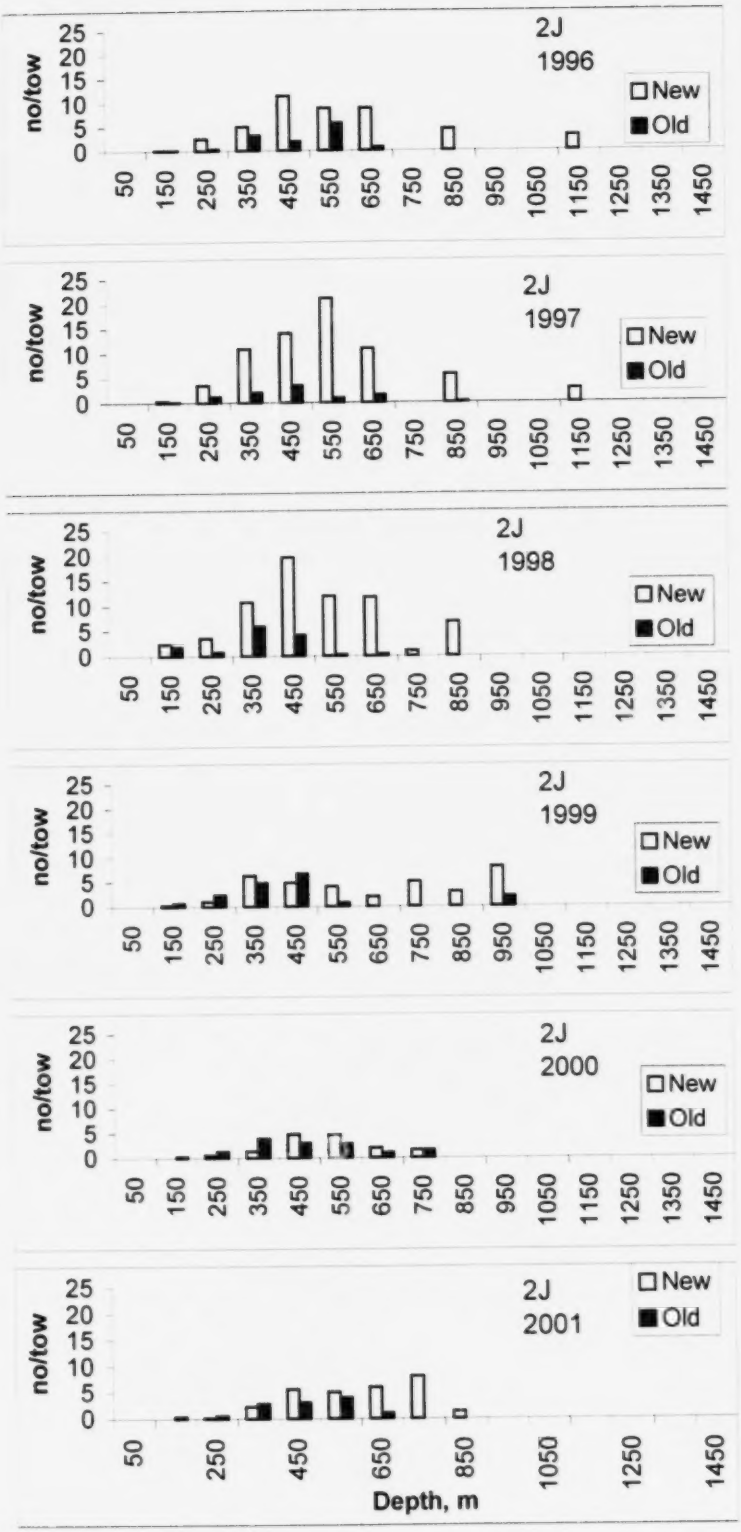

Figure 9a: Distribution of new-shelled versus old-shelled males by depth interval and year for Div. 2J.

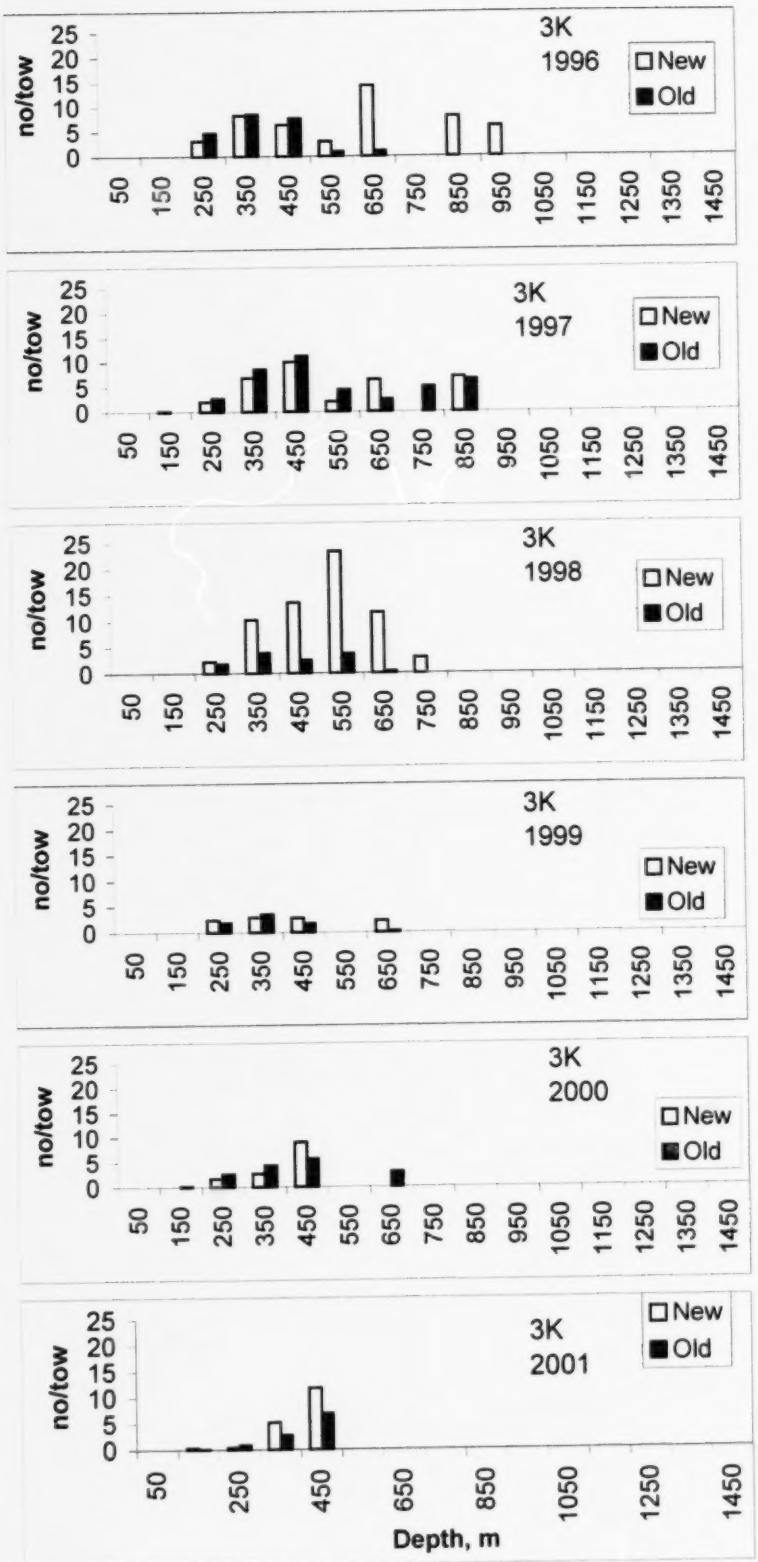

Figure 9b: Distribution of new-shelled versus old-shelled males by depth interval and year for Div. 3K.

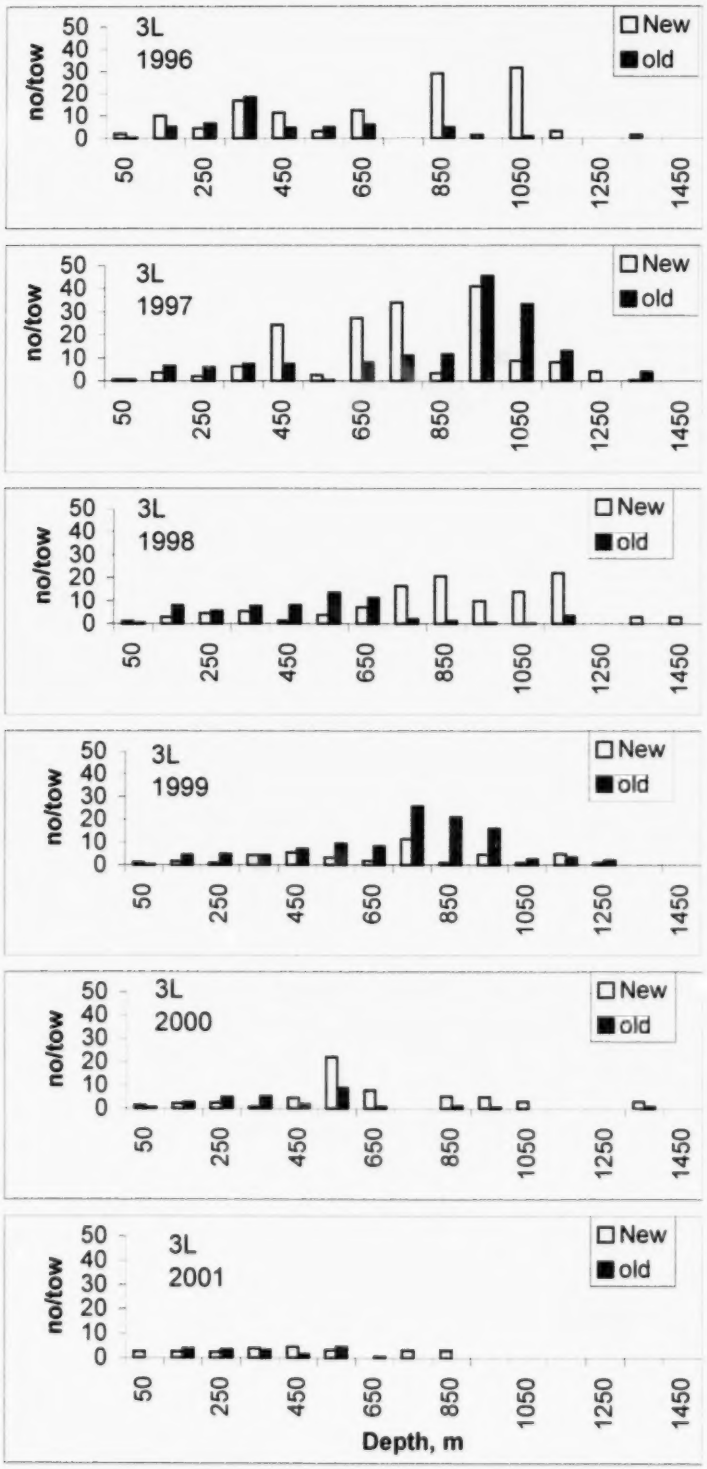

Figure 9c: Distribution of new-shelled versus old-shelled males by depth interval and year for Div. 3L.

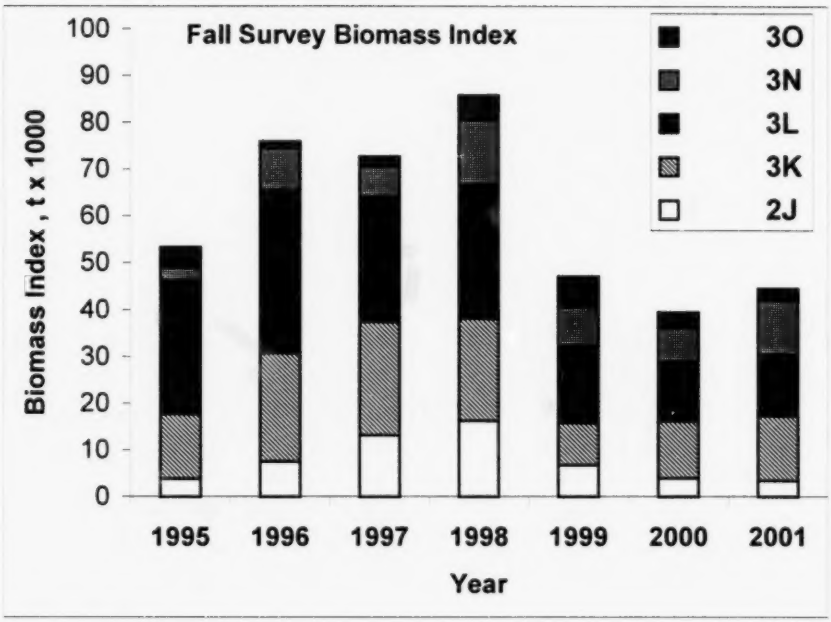

Figure 10: Minimum trawlable biomass estimates of legal-sized males by NAFO Division and year from 1995 – 2001 fall Div. 2J3KLNO multispecies bottom trawl surveys.

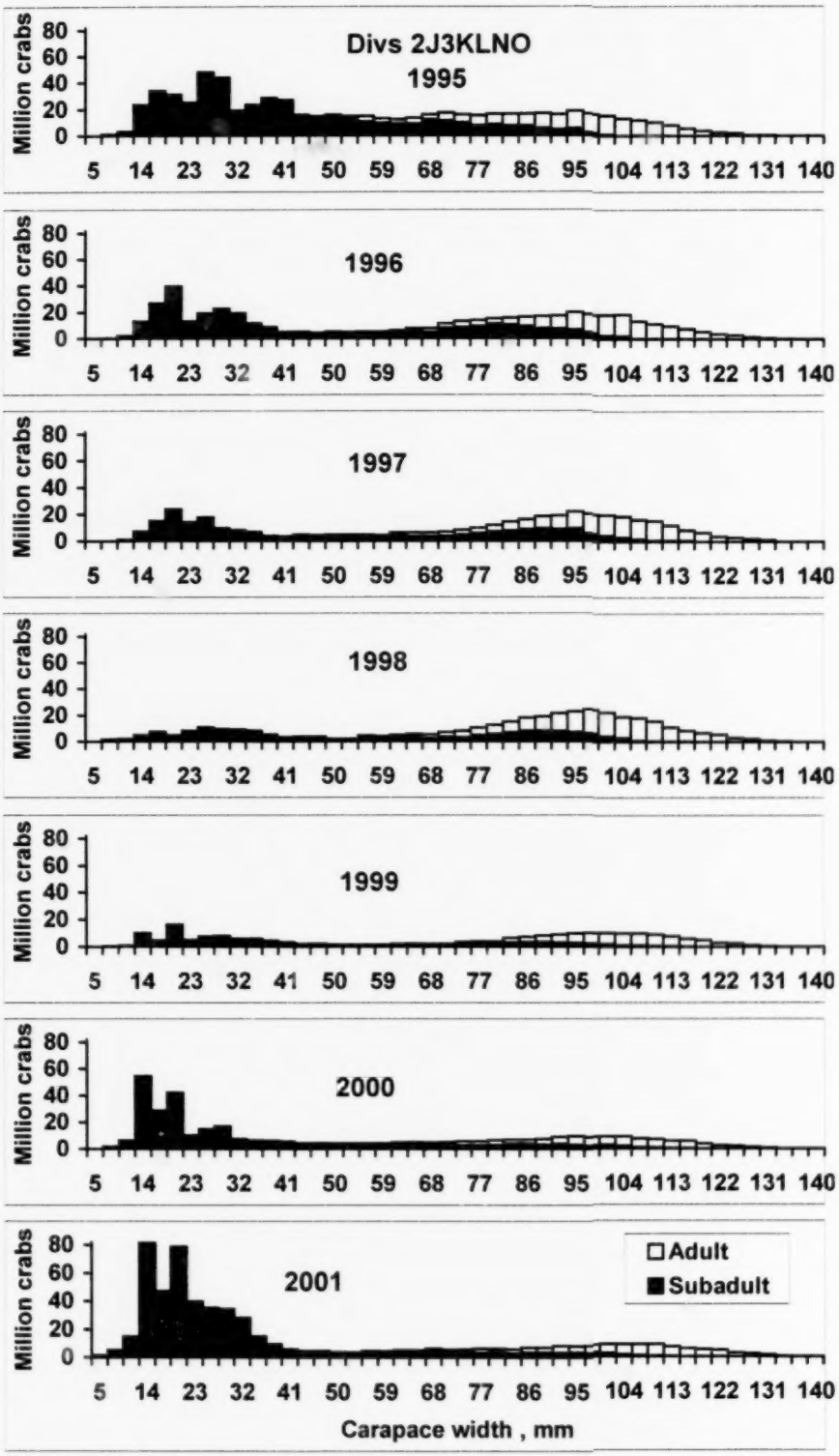

Figure 11: Male size distributions from Div. 2J3KLNO fall multispecies surveys by year and molt status.

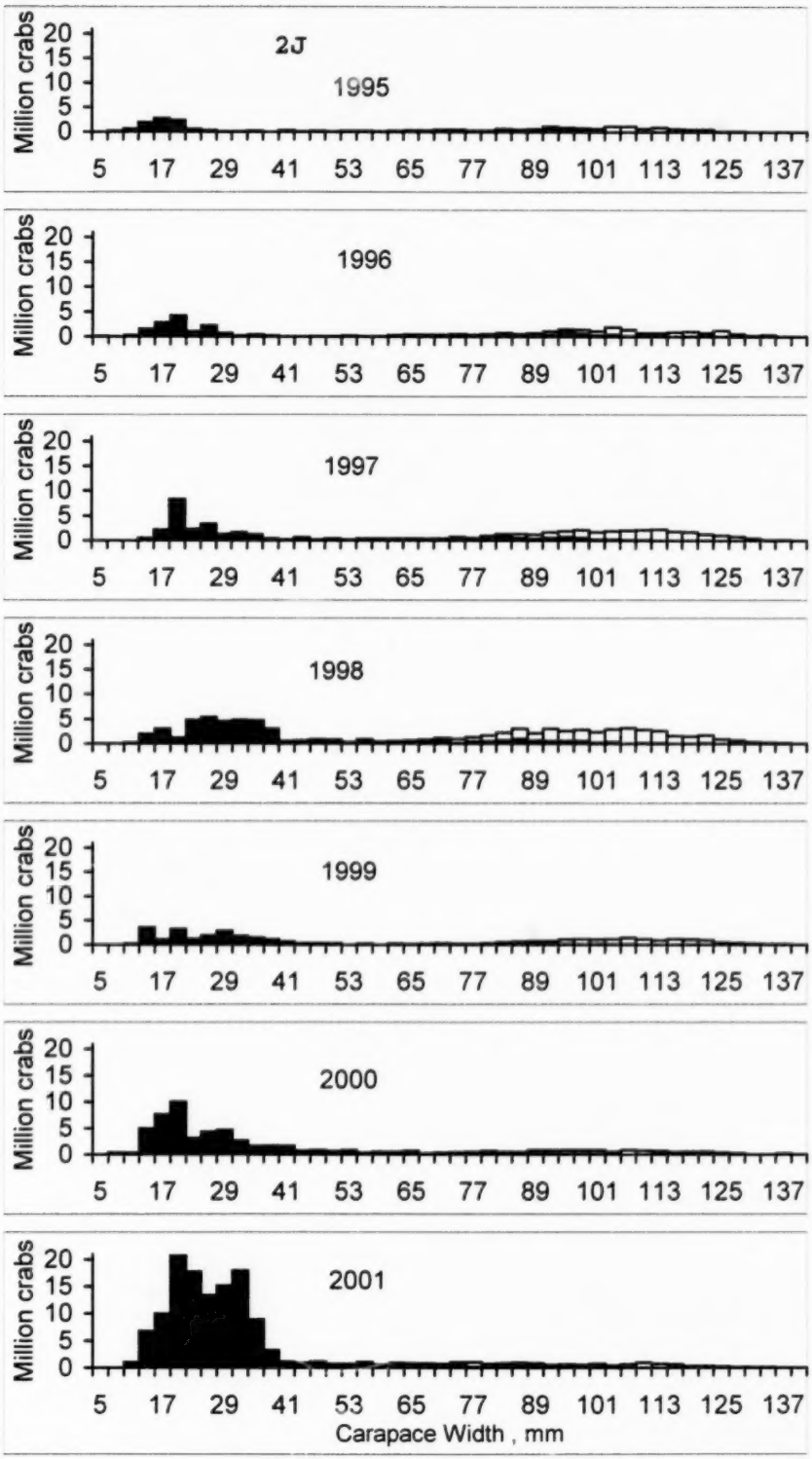

Figure 12: Annual trends in fall survey abundance index of males by carapace width, division, and molt status; juveniles plus adolescents (dark bars) versus adults (light bars).

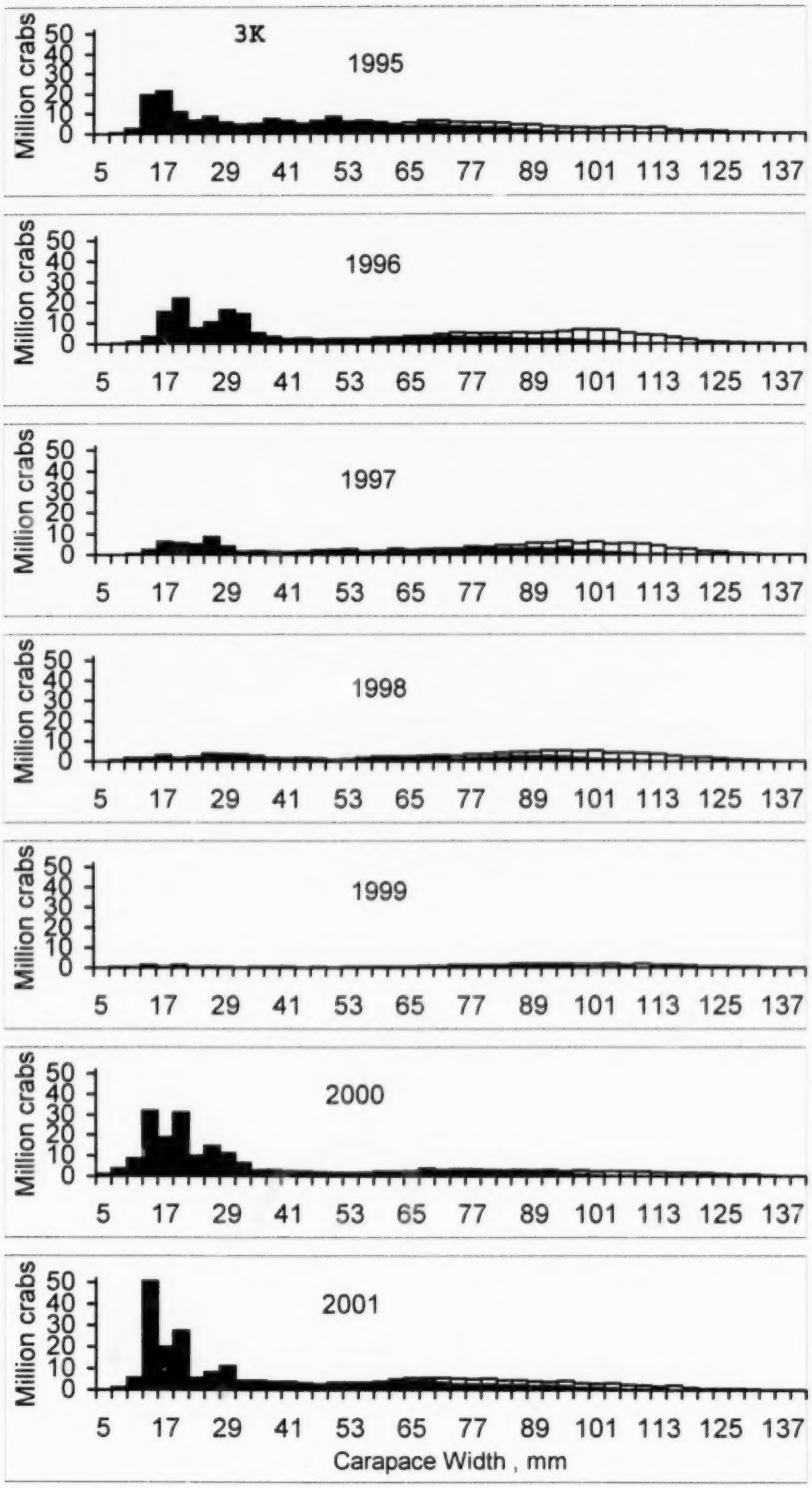

Figure 12 continued

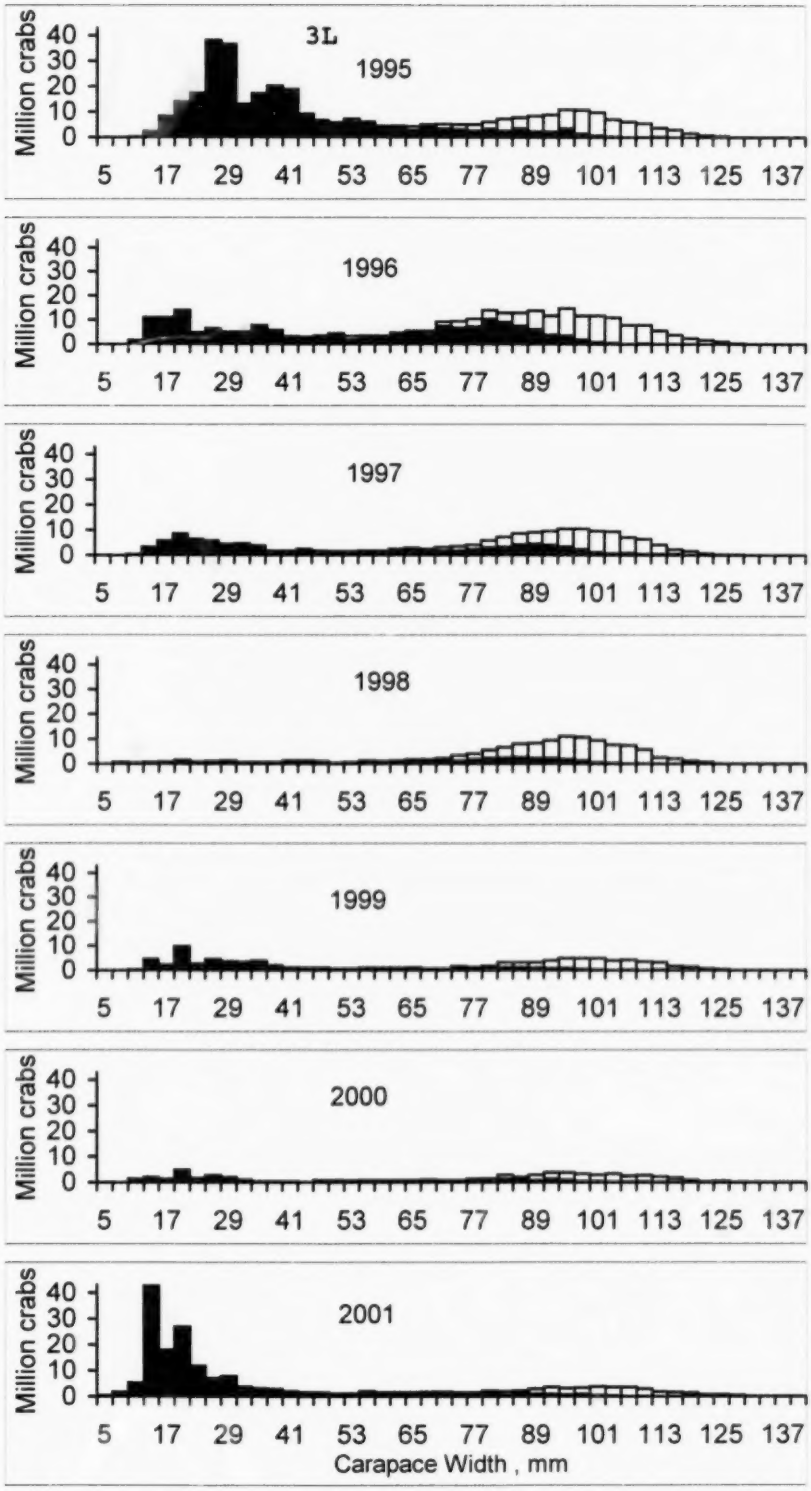

Figure 12 continued

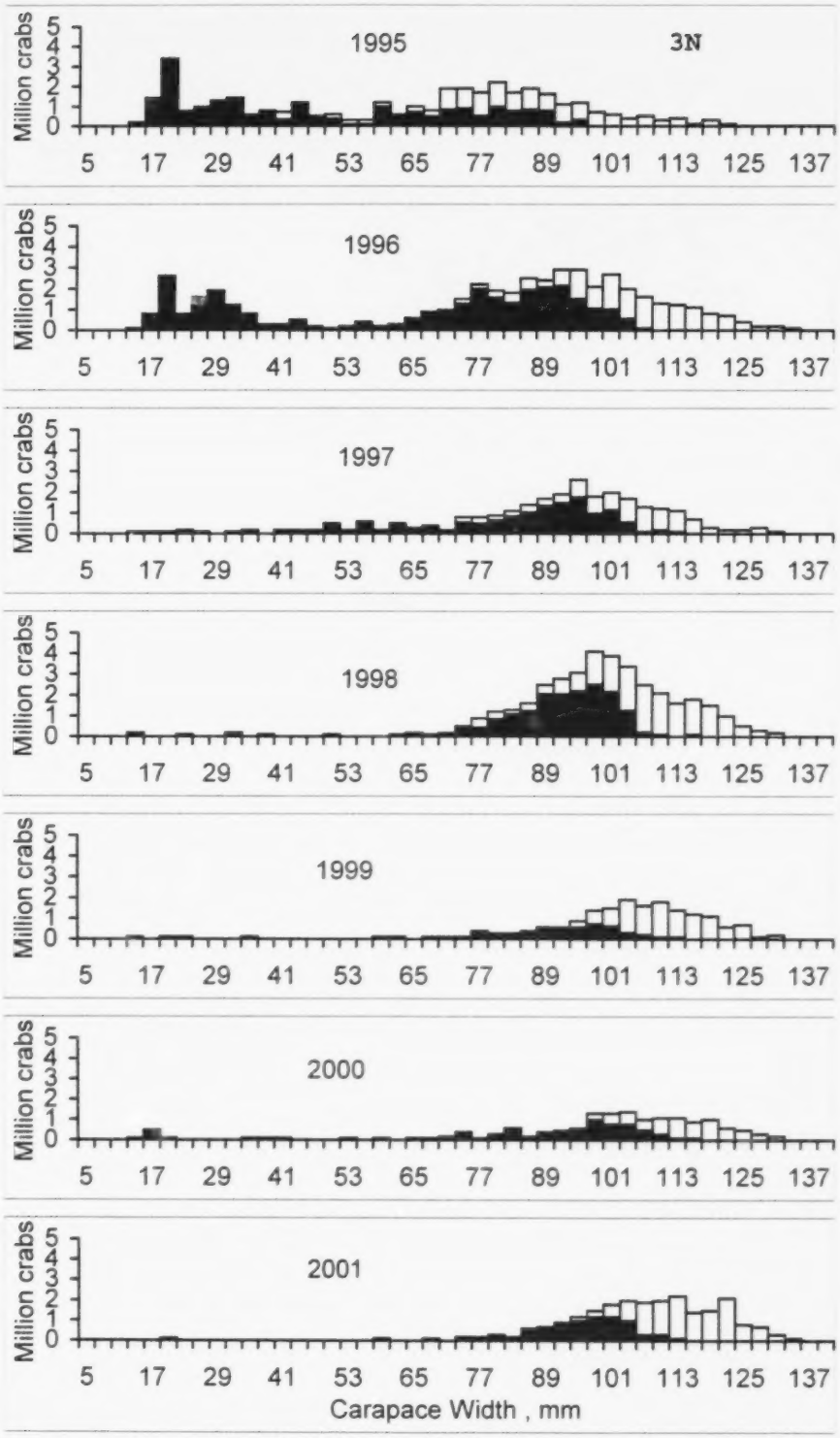

Figure 12 continued

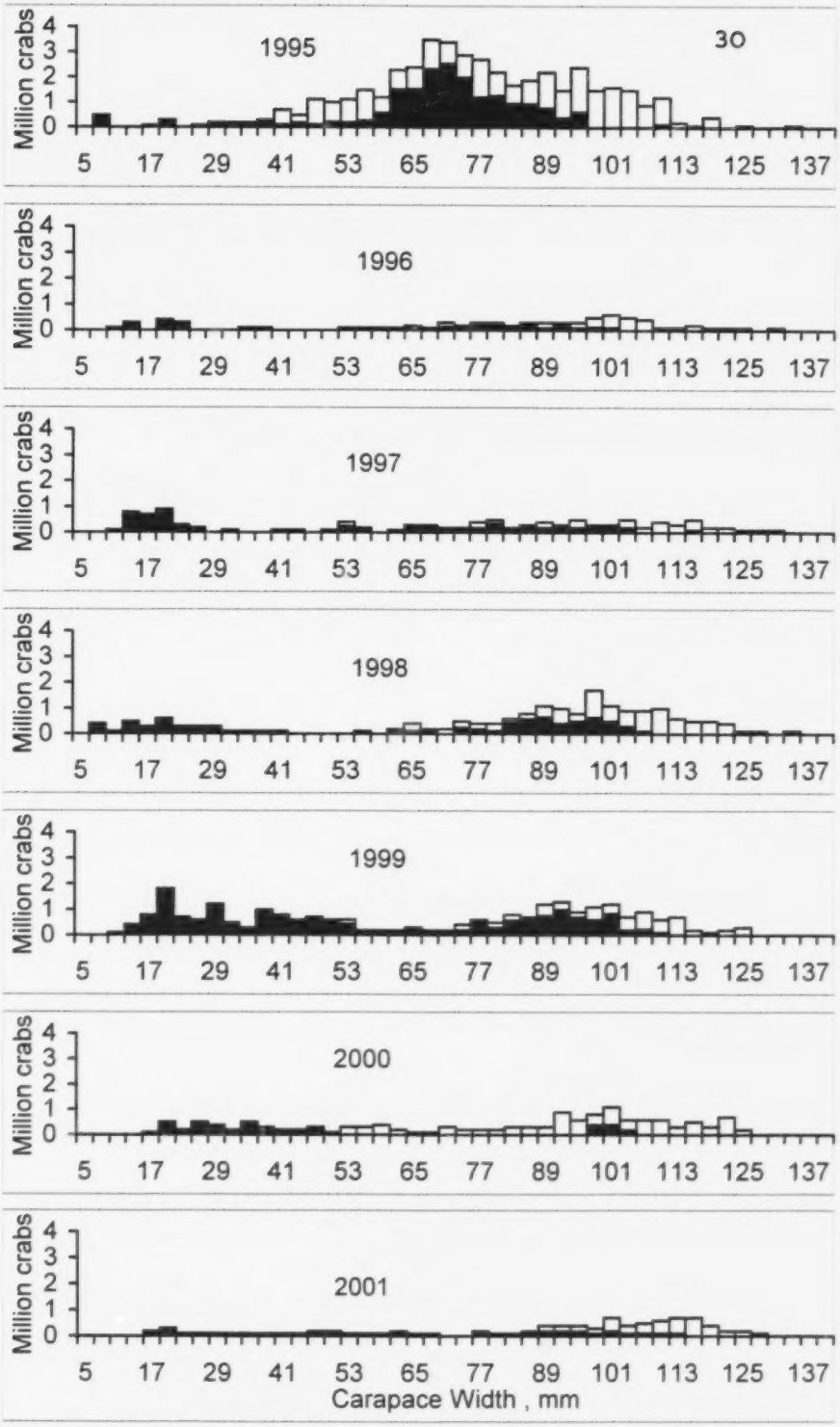

Figure 12 continued

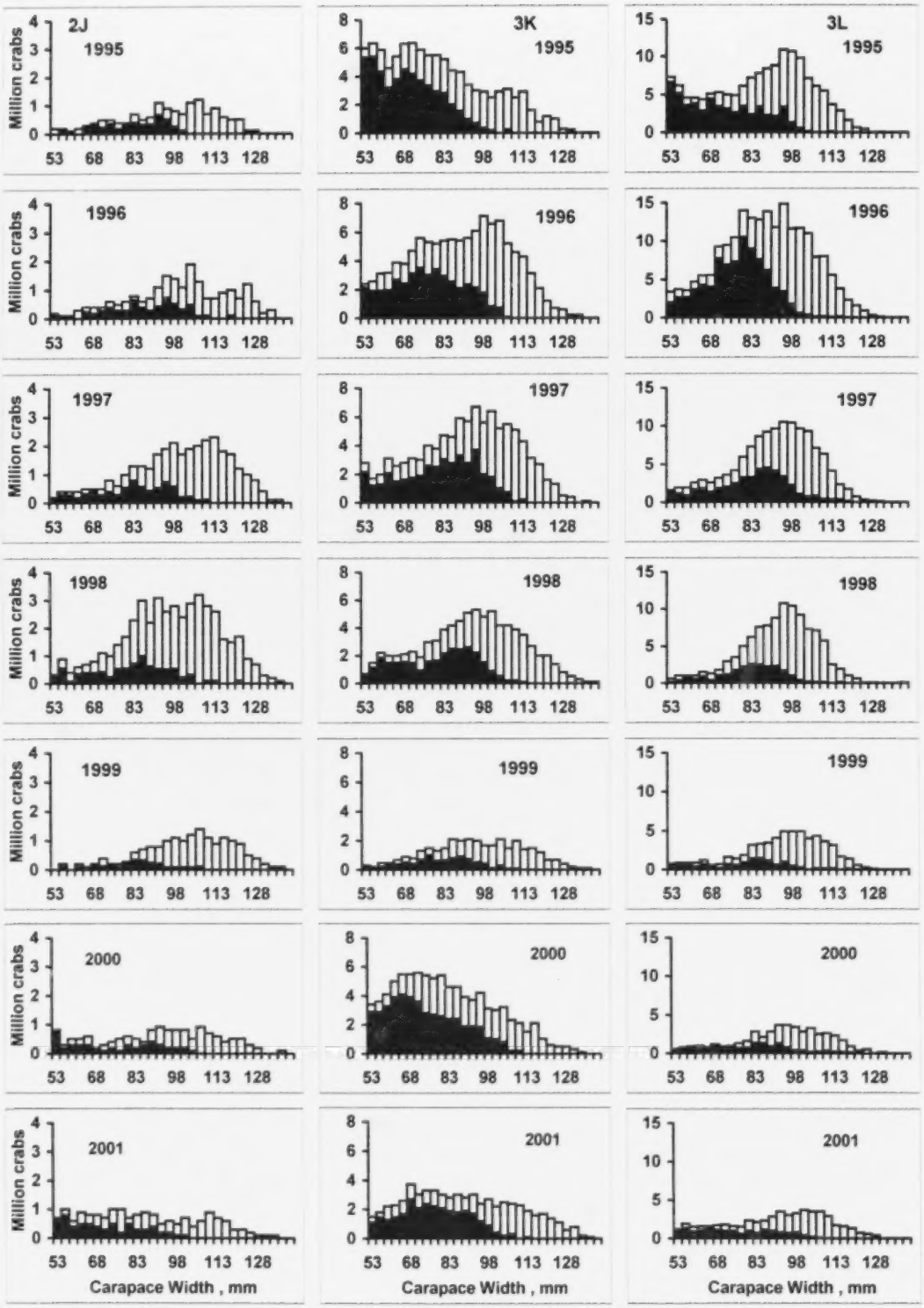

Figure 13: Size composition of males larger than 52 mm CW by division and year for Div. 2J3KL.

Table 3. Mean carapace width (mm) of legal-sized (>94 mm) males from fall surveys, by year and division.

	1995	1996	1997	1998	1999	2000	2001
2J	108.3	111.2	111.0	109.8	111.7	107.9	110.0
3K	107.9	106.5	107.3	108.5	109.3	107.0	110.1
3L	103.4	105.4	104.9	104.2	106.3	105.8	106.1
3N	104.5	106.6	104.9	108.3	111.2	111.8	111.6
3O	105.0	108.4	109.3	108.6	106.5	108.9	111.7

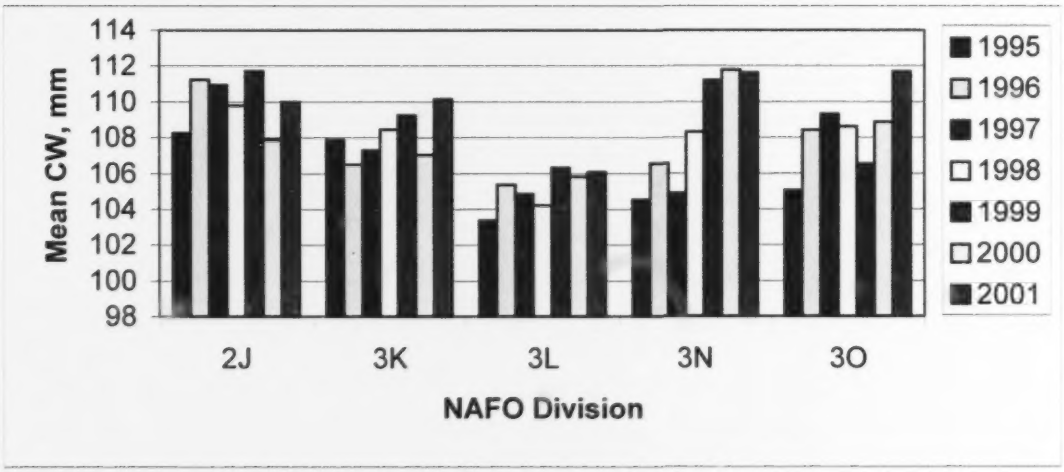

Figure 14: Mean carapace width (mm) of legal-sized (>94 mm) males from fall surveys, by year and division.

Table 4: Projected exploitable biomass indices by division, and for the entire fall survey area, by year, with 95 % confidence intervals

	1996	1997	1998	1999	2000	2001	2002
2J	2632	5947	11607	13273	6274	3549	3231
	+/-43%	+/-44%	+/-46%	+/-40%	+/-35%	+/-26%	+/-25%
3K	12912	21558	20482	18753	8416	9966	11591
	+/-46%	+/-20%	+/-22%	+/-24%	+/-30%	+/-24%	+/-39%
3L	20648	35568	25265	25068	15639	10099	12148
	+/-31%	+/-21%	+/-23%	+/-24%	+/-23%	+/-41%	+/-32%
3N	2064	6772	4539	10881	6681	5251	8970
	+/-67%	+/-71%	+/-91%	+/-104%	+/-45%	+/-65%	+/-76%
3O	3425	1449	2611	3709	4543	1104	2415
	+/-96%	+/-481%	+/-52%	+/-76%	+/-152%	+/-43%	+/-56%
Total	**41682**	**71294**	**64504**	**71684**	**41553**	**29969**	**38355**
	+/-20%	**+/-14%**	**+/-13%**	**+/-14%**	**+/-18%**	**+/-17%**	**+/-19%**

Table 5. Projected prerecruit biomass indices by division, and for the entire fall survey area, by year, with 95 % confidence intervals

	1996	1997	1998	1999	2000	2001	2002
2J	1021	1804	3239	3617	1113	1171	1254
	+/-30%	+/-38%	+/-45%	+/-36%	+/-83%	+/-46%	+/-147%
3K	7389	11114	14338	10341	3400	9539	7377
	+/-38%	+/-35%	+/-32%	+/-39%	+/-41%	+/-36%	+/-38%
3L	9580	27643	17360	9307	4715	5183	3784
	+/-41%	+/-61%	+/-437%	+/-29%	+/-48%	+/-50%	+/-47%
3N	2352	7947	6131	9875	2917	3983	4696
	+/-674%	+/-189%	+/-702%	+/-574%	+/-62%	+/-92%	+/-58%
3O	2828	879	2168	2559	8905	226	1075
	+/-83%	+/-93%	+/-92%	+/-147%	+/-171%	+/-392%	+/-80%
Total	**23,170**	**49,387**	**43,236**	**35,699**	**21,050**	**20,102**	**18,186**
	+/-25%	**+/-35%**	**+/-72%**	**+/-46%**	**+/-69%**	**+/-24%**	**+/-21%**

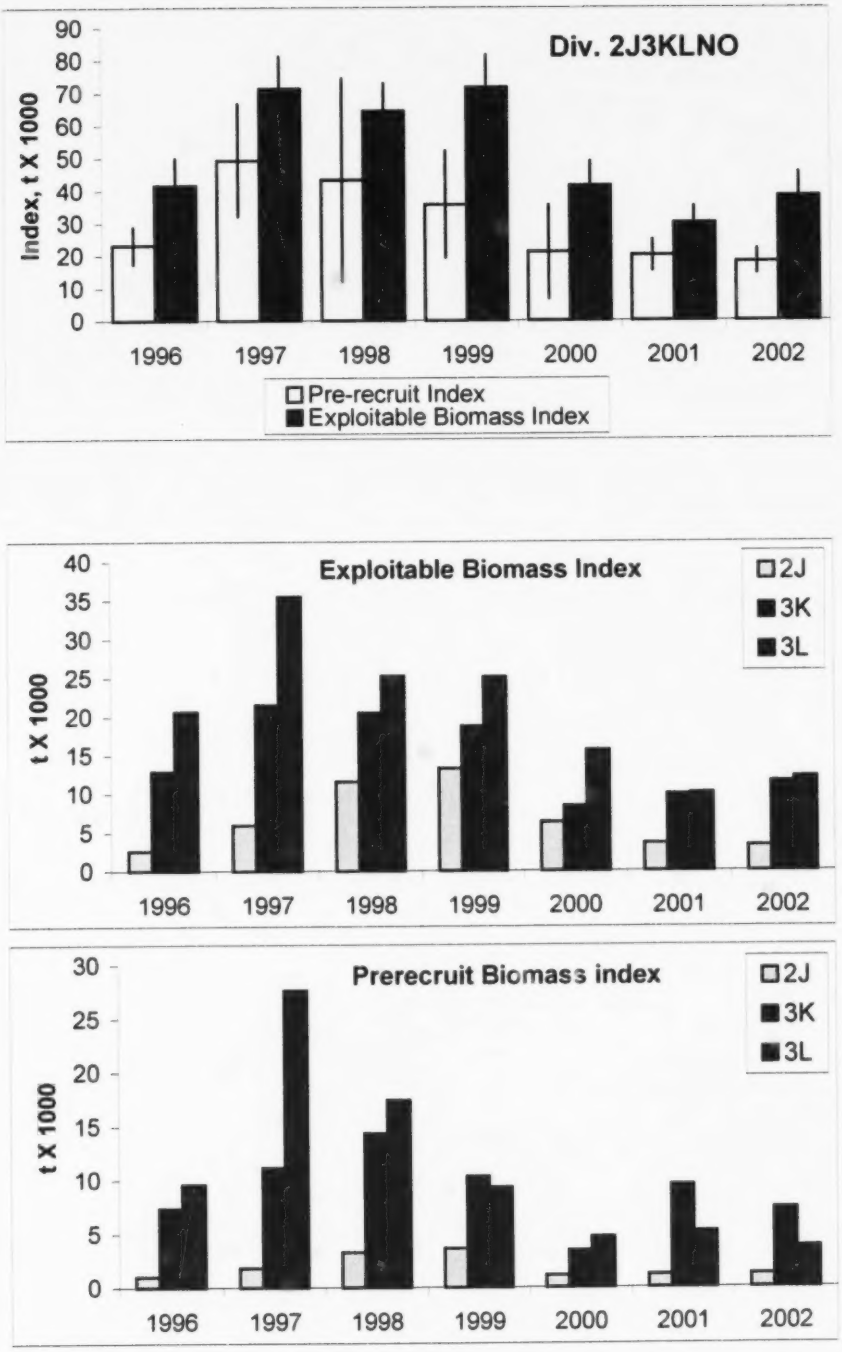

Figure 15: Projected exploitable biomass and prerecruit indices, with 95% confidence intervals, for the entire fall Div. 2J3KLNO survey area (above), and divisional indices for Div. 2J3KL (below).

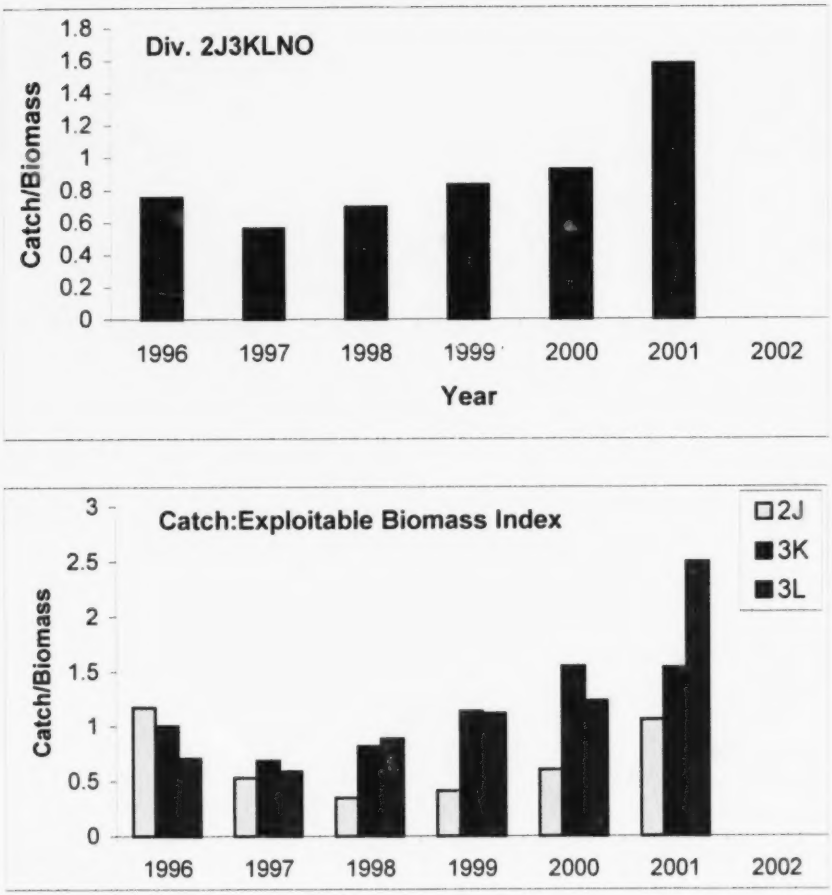

Figure 16: Annual trends in the ratio of catch to the projected exploitable biomass index for the entire fall Div. 2J3KLNO survey area (above), and divisional ratios for Div. 2J3KL (below).

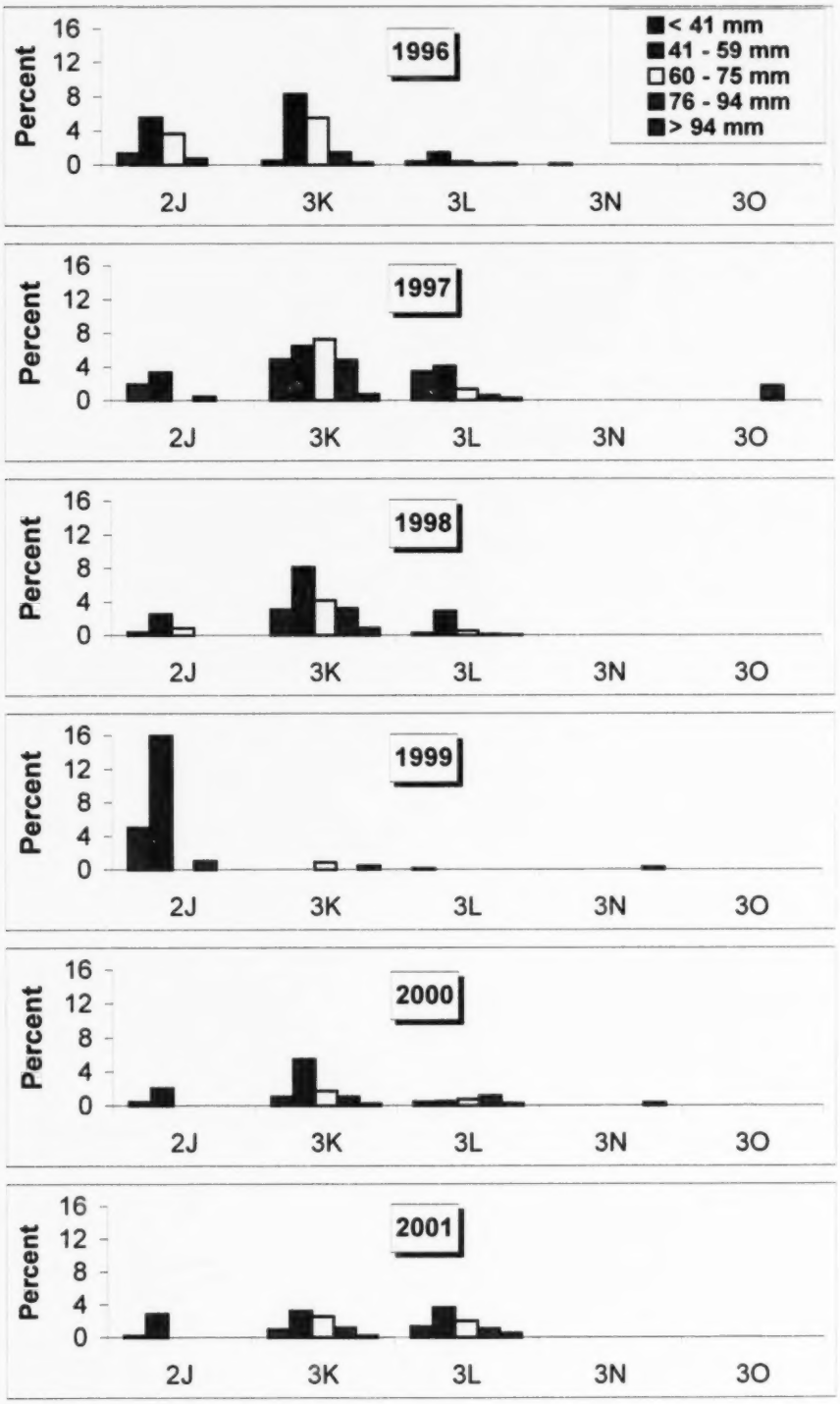

Figure 17: Percent of recently-molted male snow crabs infected with bitter crab disease (BCD) by division, size group and year, from fall surveys.

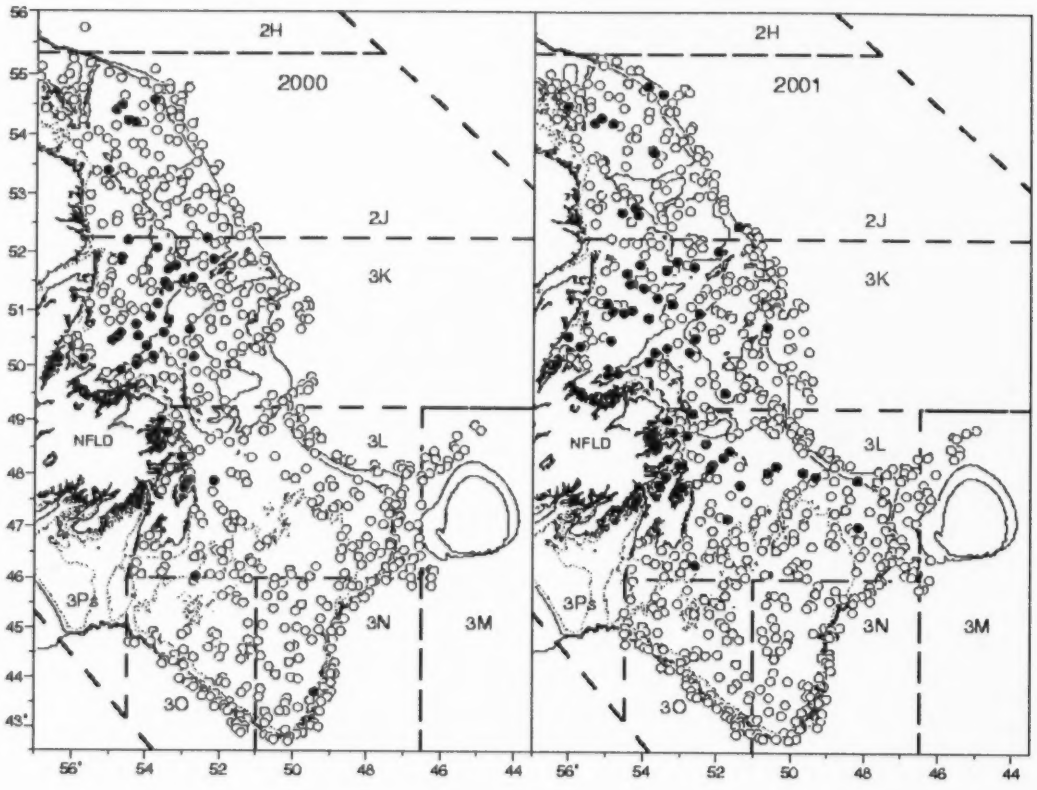

Figure 18: Distribution of sets in which BCD was encountered (closed circles) versus sets in which BCD was not observed (open circles), from 2000-2001 fall multispecies surveys.

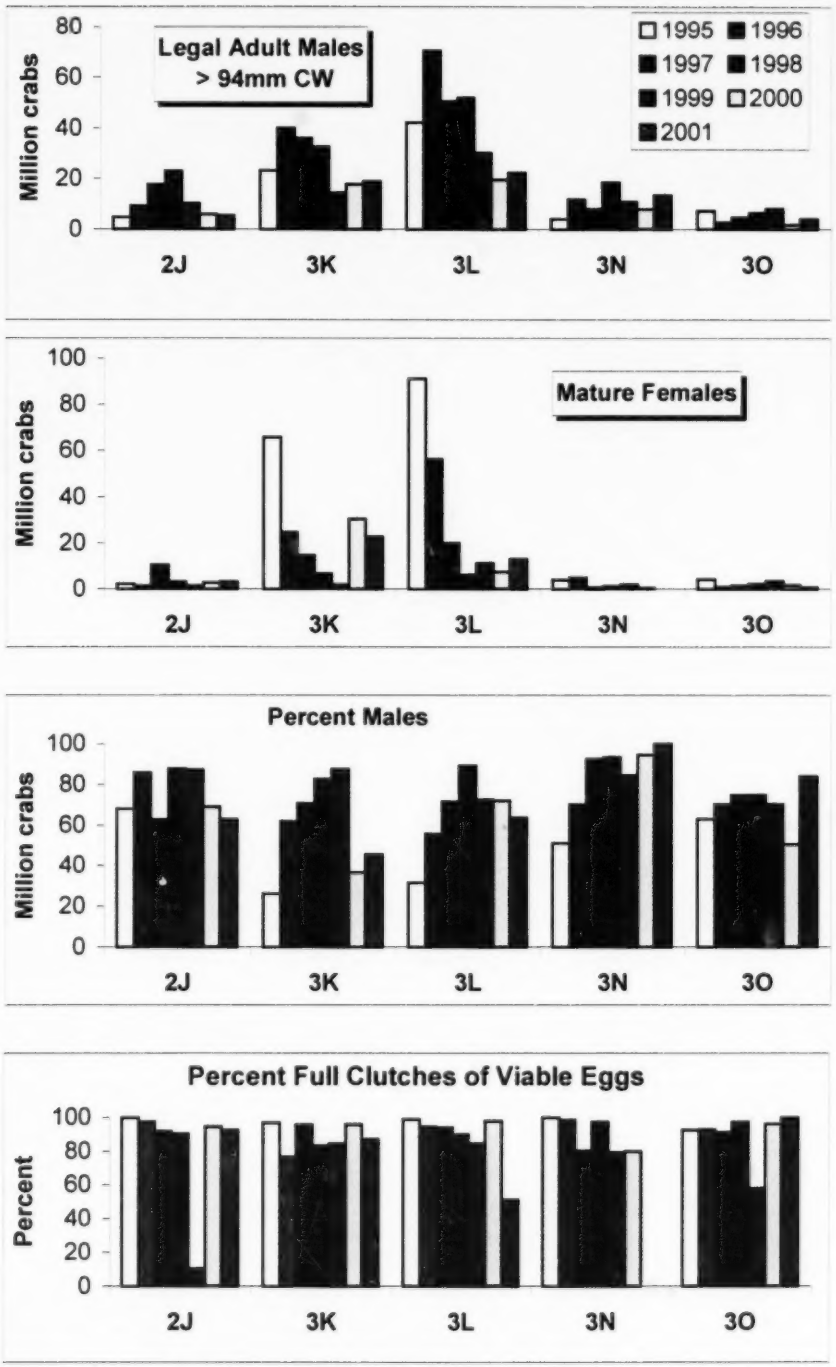

Figure 19: Fall survey abundance indices of legal-sized adult males and mature females (upper two panels), percentage males of those two groups (third panel), and percentage of mature females bearing full clutches of viable eggs (bottom).

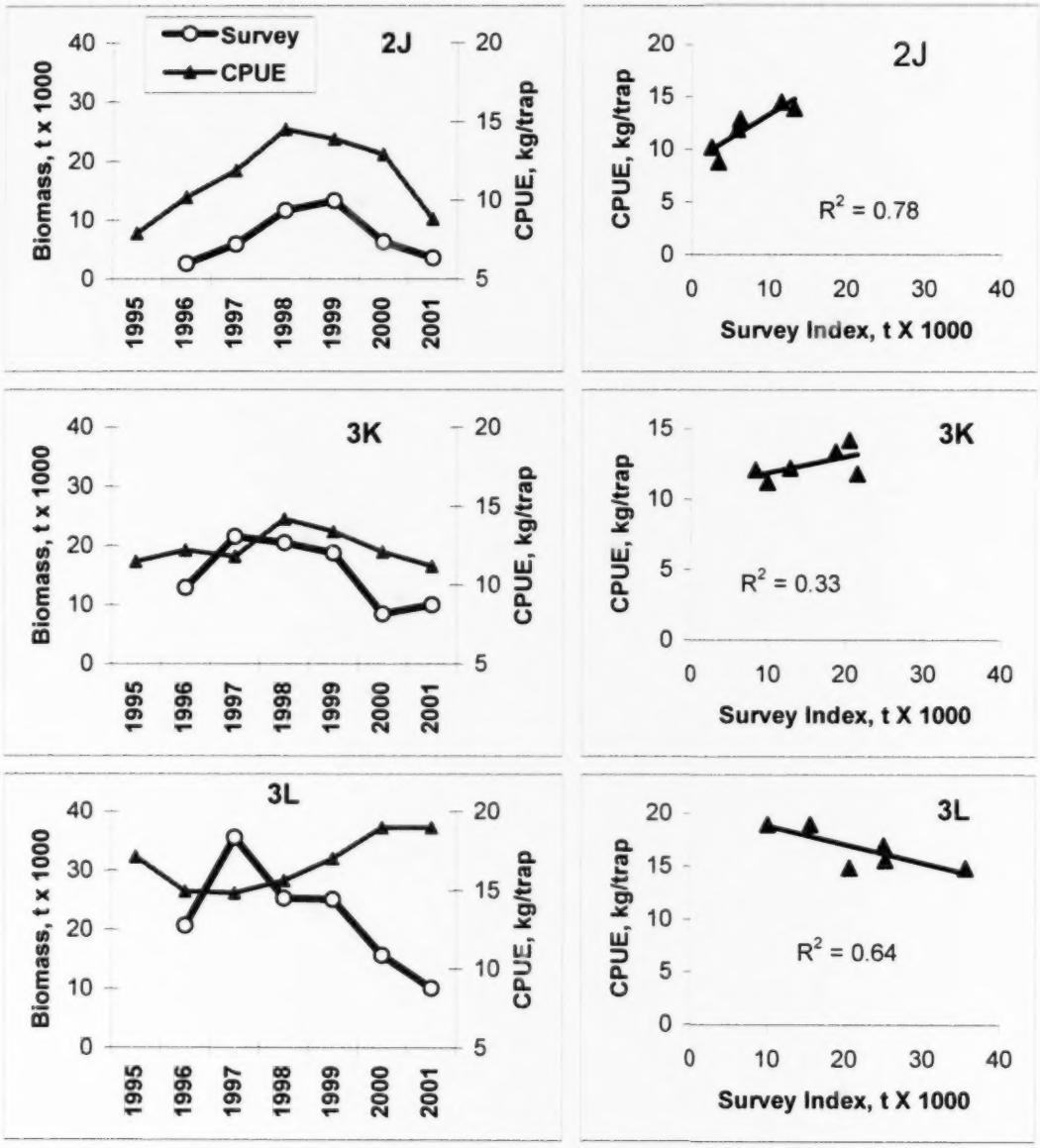

Figure 20: Relationship between the exploitable biomass index (from the fall survey in the previous year) and CPUE for Div. 2J, 3K, and 3L.

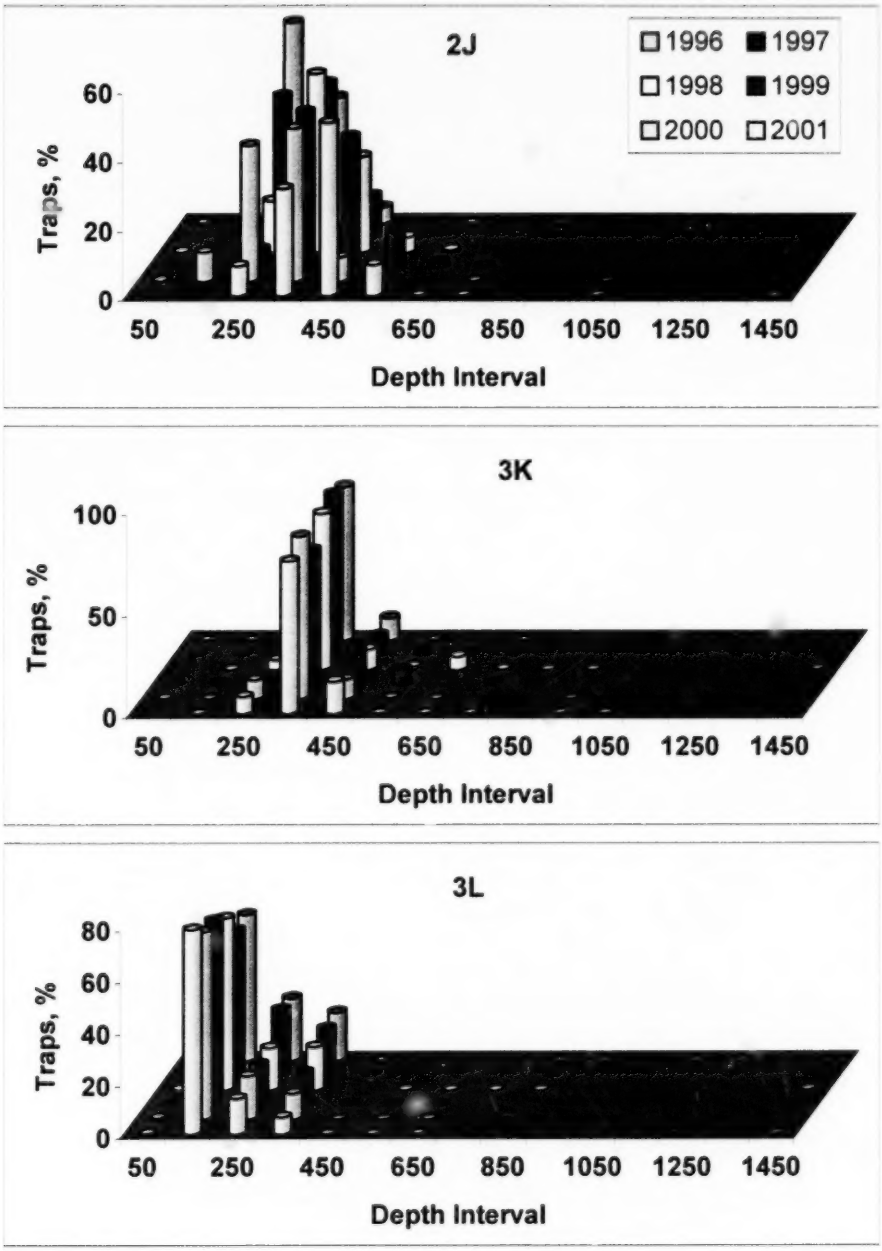

Figure 21: Yearly trends in depth distribution of commercial fishing effort for Div. 2J, 3K, and 3L.

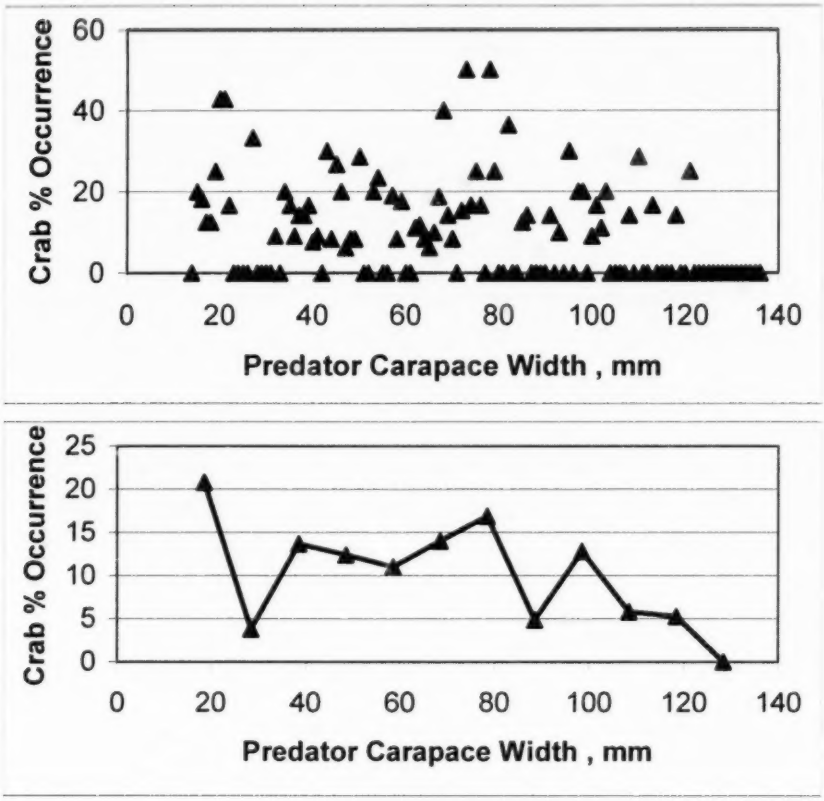

Figure 22: Percent Occurrence of crabs in crab stomachs by carapace width (above) and by 10 mm carapace width interval (below), Stomachs are from crabs collected in Div. 3K during the fall 2000 multispecies survey.